Chapter 8

Groundwater Development and Basinwide Water Balance

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Several factors to consider when planning a groundwater development project include:

- Is the resource economically accessible utilizing current drilling, well construction, and water delivery technology?
- Is the water quality sufficient to meet the requirements of its intended use in either an untreated form or following cost effective treatment?
- Is the resource legally available? Legal and political considerations such as competing local water rights, aquifer and surface water depletion, and wildlife impacts constrain groundwater availability under the developing concept of sustainability.
- Can the aquifer provide sufficient quantities of water? Quantity pertains to the rate and duration of production that can be reasonably expected from the completed project wells.

Project engineers, scientists, water managers, operations personnel, and end users continuously evaluate these interrelated factors during a project because a substantial deficiency in any one area may undermine the entire project.

To effectively discuss groundwater development and use within a river basin, the term "withdrawal" and the concept of "consumptive use" must be defined and discussed. A groundwater withdrawal is simply the removal of a volume of water from a well, or a spring at its source. The consumptive use of a water resource, however, diminishes the amount of water available for other uses and effectively removes that water as a useable resource from the drainage basin. Consumptive processes include plant and animal growth, evaporation, transpiration, some industrial processes, and injection into geologic units where depth and water quality preclude future withdrawal.

Relatively few uses are wholly consumptive or non-consumptive. Most uses are partially consumptive in that some of the water is lost while the remainder is returned to the system. For instance, a portion of the groundwater used for irrigation is lost to the consumptive processes of evapotranspiration and plant growth while the remainder is delivered back to the basin's water budget in the form of return flows to surface waters or as recharge to groundwater. Other examples of partially consumptive uses (with the associated, consumptive constituent noted in parentheses) include livestock watering (animal growth and evaporation), reservoir storage (evapotranspiration), and domestic wastewater treatment including discharge from sewage or septic systems (evapotranspiration). Other uses, such as industrial wastewater storage and disposal in evaporation pits and water injection for enhanced oil and gas production, are considered to be fully consumptive. Throughout this study "use" has essentially the same meaning as "withdrawal," and "depletion" has the same meaning as "consumptive use." The preferred terms, in an attempt to minimize confusion, are "withdrawal" and "consumptive use."

This chapter discusses groundwater development, total withdrawals, and consumptive uses in the Snake/Salt River Basin using information compiled from multiple sources:

- Previous and current water plans for the Snake/Salt River Basin (Sunrise Engineering, 2003; WWDO, 2014);
- Numerous previous local and regional studies (**appendix B**, **chapter 7**);
- Groundwater permit data provided by the Wyoming State Engineer's Office (SEO) and the Idaho Department of Water Resources (IDWR); and
- SEO 2012 *Hydrographers' Annual Report Water Division 4* (SEO, 2013) available at: https://sites.google.com/a/wyo.gov/seo/documents-data/hydrographer-reports/division-iv-annual-reports.

8.1 Information from previous water plans

Total groundwater withdrawals, consumptive uses, and the methods used to quantify them in the Snake/Salt River Basin were described in the existing WWDC Statewide Framework Water Plan

(WWC Engineering and others, 2007), which compiled information from the 2003 Snake/Salt River Basin Water Plan (Sunrise Engineering, 2003), associated technical memoranda, and other on-line publications. Although the 2007 Statewide Water Plan summarized withdrawal and consumptive use information developed in the 2003 Snake/Salt River Basin Plan, there were differences in the volumes reported between the two plans and the various technical memoranda. Direct measurements of irrigation uses were not provided in the WWDC Water Plans but were estimated based on related information. Estimates of consumptive uses associated with the environmental uses of groundwater resources were not provided in the previous plans or technical memoranda.

8.2 Groundwater withdrawal and consumptive use estimations in this memorandum and basin-wide water balance

In the absence of direct measurements, groundwater withdrawals and consumptive uses must be estimated. While this may appear to be straightforward, in reality, it becomes quite complex because multiple estimations of the same parameter may be made using different methods and assumptions. Still, the methods used must provide reasonably conservative estimations of withdrawals and consumptive uses based on rational assumptions. Therefore, withdrawal and consumptive use values are presented, in the tables shown below, in multiple formats and as ranges of probable values. In some cases, very conservative estimations have been provided for comparison and are explained in the text that accompanies the table. See, for example, the range of annual irrigation withdrawal estimates from SEO data made in rows 2 - 3 of **table 8-1a**.

The water resources of any river basin are not composed of static volumes of standing water. Unlike an area's mineral reserves, water is a dynamic resource that enters a basin in the form of precipitation or as surface and groundwater flows from adjacent areas. Likewise, water exits a river basin as effluent surface and groundwater flows or as water vapor resulting from evaporation, and transpiration from plants (see definition, **chapter 5**). It is important to understand the transient nature of water resources. For this reason, the Wyoming State Geological Survey (WSGS) generated a basin-wide water balance (**tables 8-2a** and **8-2b**) to provide an understanding of the magnitude, origin, and fate of water resources in the Snake/Salt River Basin.

8.2.1 Groundwater withdrawal and consumptive use estimations

Tables 8-1a through **8-1e** summarize and compare various groundwater withdrawal and consumptive use estimates from the SEO and previous WWDC water plans and technical memoranda (WWC Engineering and others, 2007; Sunrise Engineering, 2003; WWDO, 2014) for principal SEO listed water right uses. Some consumptive use estimates were obtained from *Technical Memorandum V, Future Water Use Projections* (BBC Research and Consulting, 2002) of the 2003 Snake/Salt River Basin Water Plan (Sunrise Engineering, 2003). For this study, WSGS prorated 2002 annual consumptive use levels to those projected for 2032 from Technical Memorandum V to estimate uses in the basin for 2013. Consumptive use estimates from the median economic growth - normal water-demand year scenario were used for each "economic sector" (Agricultural, Municipal/ Rural Domestic Water Systems, Industrial and Recreational). These economic sectors combine the principal SEO-listed water right uses and, in addition, quantify consumptive uses resulting from recreational activities:

- Irrigation and stock watering are combined as agricultural uses (**table 8–1a**);
- Industrial uses (**table 8–1b**);
- Municipal supply and rural domestic are combined as municipal/water systems (**table 8–1c**);
- In the Snake/Salt River Basin, recreational uses (**table 8-1d**) consist primarily of snow-making at the area's ski resorts and golf course irrigation. Recreational uses, listed by the SEO under "Miscellaneous Uses" (SEO, 2014), are of significant

Table 8-1a. Groundwater withdrawal and consumptive use estimates for agricultural use wells (irrigation and stock watering) in the Wyoming portion of the Snake/Salt River Basin.

Use	Annual withdrawal (ac-ft/yr)	Annual consumptive-use (ac-ft/yr)	Percent consumptive use	Estimation method/ Data sources/ Notes
[a] SEO permitted irrigation wells	30,869	no estimate		SEO permitted yields for irrigation wells through 02/27/12. (See Table 8-6)
	11,760	no estimate		SEO permitted yields for likely existing irrigation wells through 02/27/12. (See Table 8-6)
[a] SEO permitted livestock wells	5,794	no estimate		Total permitted yield through 02/27/12. (See Table 8-6)
	4,786	no estimate		Permitted yield for likely existing stock wells through 02/27/12. (See Table 8-6)
[b] Agricultural uses	no estimate	700	no estimate	Irrigation and livestock use estimates are aggregated as agricultural uses. Consumptive use estimate is pro-rated from 2002 and projected 2032 estimates in 2003 Snake/Salt River Basin Water Plan; normal demand mid growth scenario.

[a] Wyoming State Engineer's Office, 2012
[b] Sunrise Engineering, 2003

Table 8-1b. Groundwater withdrawal and consumptive use estimates for industrial use wells in the Wyoming portion of the Snake/Salt River Basin.

Use	Annual withdrawal (ac-ft/yr)	Annual consumptive-use (ac-ft/yr)	Percent consumptive use	Estimation method / Notes
[a] Permitted industrial wells	1,312	no estimate		Total permitted yield through 02/27/12. (See Table 8-6)
	792	no estimate		Total permitted yield for likely existing wells through 02/27/12. (See Table 8-6)
[b,c] Industrial uses	50	50	-----	Consumptive use estimate is pro-rated from 2002 and projected 2032 estimates in 2003 Snake/Salt River Basin Water Plan; normal demand mid growth scenario.
	0	0		Estimated industrial water use for 2012 made by WWDO for the Snake/Salt River Basin Water Plan.
[d] WOGCC Conventional Oil & Gas produced water (2005-2011)	0	0	-----	WOGCC records show that all oil and gas wells in the Snake/Salt River Basin are plugged and abandoned and that there has been no production for the last three decades.

[a] Wyoming State Engineer's Office, 2012
[b] Sunrise Engineering, 2003
[c] Wyoming Water Development Office, 2014
[d] Wyoming Oil and Gas Conservation Commission, 2013

Table 8-1c. Groundwater withdrawal and consumptive use estimates for municipal and domestic use wells in the Wyoming portion of the Snake/Salt River Basin.

Use	Annual withdrawal (ac-ft/yr)	Annual consumptive-use (ac-ft/yr)	Percent consumptive use	Estimation method / Notes
[a] Permitted municipal and domestic wells	130,591	no estimate		Total permitted yield through 02/27/12. (Table 8-6)
	110,187	no estimate		Permitted yield for likely existing wells through 02/27/12. (Table 8-6)
[b] Public Water Supplies/Rural domestic	14,100	8,400	60%	Aggregated domestic and municipal use (incl. associated commercial and subdivision uses); Withdrawal/consumptive use estimate pro-rated from 2002 and projected 2032 estimates in 2003 Snake/Salt River Basin Water Plan; normal demand mid growth scenario.
[c] Public Water Supplies/Rural domestic	No estimate	8,865	No estimate	Estimated combined municipal and rural domestic water use for 2012 made by WWDO for the Snake/Salt River Basin Water Plan

[a] Wyoming State Engineer's Office, 2012
[b] Sunrise Engineering, 2003
[c] WWDO, 2014

Table 8-1d. Groundwater withdrawal and consumptive use estimates for recreation in the Wyoming portion of the Snake/Salt River Basin.

Use	Annual withdrawal (ac-ft/yr)	Annual consumptive-use (ac-ft/yr)	Percent consumptive use	Estimation method / Notes
[b] Recreational Uses	no estimate	150	no estimate	Recreational uses assumed to consist primarily of golf course irrigation and snow making at basin ski resorts. Consumptive use estimate pro-rated from 2002 and projected 2032 estimates in 2003 Snake/Salt River Basin Water Plan; normal demand mid growth scenario.

[a] Wyoming State Engineer's Office, 2012
[b] Sunrise Engineering, 2003

magnitude to include in this report; and
- Other diverse uses (**table 8–1e**) that involve miscellaneous, monitoring, testing, and multi-use wells are hereinafter referred to as minor uses.

Additionally, consumptive use estimates are provided from the 2012 Snake/Salt River Basin Plan Update (WWDO, 2014) for comparison to the values prorated from Technical Memorandum V of the 2003 Snake/Salt River Basin Plan (Sunrise Engineering, 2003). In cases where consumptive use estimates differ, the higher value is used in summary tables, such as **table 8-1f**. Finally, although the values developed for **tables 8-1a** through **8-1f** and **tables 8-2a** through **8-2d** are shown in some cases to a precision of one ac-ft., they are generally rounded to the nearest 50 ac-ft. in the following discussions. Percentages are typically carried to one decimal place in the tables; in some cases small percentages were carried to two decimal places (**table 8-2c**).

Estimates of total withdrawal and consumptive use volumes for the five economic sectors listed above are shown in **tables 8-1a** through **8-1e** and are aggregated in **table 8-1f**. Irrigation and stock watering uses are combined as agricultural uses in **table 8-1a**, and public supply and rural domestic uses are combined in **table 8-1c**. Total annual groundwater withdrawal is estimated at 14,600 ac-ft and the highest estimated value for annual consumptive use is 9,700 ac-ft (**table 8-1e**). Water use categories, amounts, and estimation methods are discussed in more detail later in this chapter. Minor uses are not included in the totals shown in **table 8-1f** because only SEO permitted withdrawal data (**table 8-1e**) is available and they were not addressed in previous water plans.

For other uses, potential volumes calculated from SEO allocated well yields are provided for comparison to consumptive use estimates obtained from previous technical memoranda. The large differences between SEO allocated well yields and actual use estimates show that the volumes of groundwater actually used constitute, in most cases, a minor fraction of what has been allocated to permitted water right holders. For example, the total irrigation withdrawal calculated from SEO permitted yields for "likely existing wells" (11,760 ac-feet/yr in **table 8-1a**) assumes continuous year-round operation of the permitted irrigation wells. Although, the value is clearly an overestimate, it does provide an instructive upper limit of groundwater withdrawals for irrigation that may be readily compared to estimates of actual consumptive uses. The estimates shown for agricultural withdrawals and consumptive uses of groundwater are aggregate values for both irrigation and stock watering (Sunrise Engineering, 2003). Irrigation consumptive uses in that report were based primarily on actual crop specific consumptive uses specified in Pochop and others (1992) applied to crop distribution data obtained from the agricultural industry in the Snake/Salt River Basin. The methodologies employed are explained in appendices D, E, F, G and P of the 2003 Snake/Salt River Basin Water Plan (Sunrise Engineering, 2003).

Table 8-1a estimates total groundwater withdrawals and consumptive uses for irrigation and stock watering (combined as agricultural uses) obtained from various sources. Values from Technical Memorandum V (BBC Research and Consulting, 2002) of the 2003 Snake/Salt River Basin Water Plan (Sunrise Engineering, 2003) shown in **table 8-1a** are used in **table 8-1f**.

Table 8-1b estimates various classes of industrial groundwater withdrawals and consumptive uses compiled from SEO and WOGCC data and the 2012 Snake/Salt River Basin Water Plan (WWDO, 2014). The 2003 Snake/Salt River Basin Water Plan (Sunrise Engineering, 2003) identified three primary industrial water users: Star Valley Cheese Company, Northern Food, and Dairy and Water Star Bottling Company. Currently there is no significant industrial water use in the basin because operations have ceased at all three companies (WWDO, 2014). Historically, these industrial water demands were supplied from municipal groundwater sources in Thayne and Afton (BBC Research and Consulting, 2002).

WOGCC records indicate that there has been no production or injection of groundwater from oil

Table 8-1e. Permitted annual groundwater withdrawal rates for SEO monitor, multi-use and other wells in the Wyoming portion of the Snake/Salt River Basin.

SEO permitted use	[a]Annual withdrawal (ac-ft/yr)	Annual consumptive-use (ac-ft/yr)	Estimation method / Notes (See Table 8-6)
Permitted monitor wells	0.0	no estimate	Total permitted yield through 02/27/12
	0.0	no estimate	Permitted yield for likely existing wells through 02/27/12
Permitted "other wells"	268,938	no estimate	Total permitted yield through 02/27/12
	121,792	no estimate	Permitted yield for likely existing wells through 02/27/12
Permitted "multi-use wells"	44,053	no estimate	Total permitted yield through 02/27/12
	27,693	no estimate	Permitted yield for likely existing wells through 02/27/12

[a] Wyoming State Engineer's Office (2012)

Table 8-1f. Total groundwater withdrawal and consumptive use estimates for all uses in the Snake/Salt River Basin.

Use	Annual withdrawal (ac-ft/yr)	Annual Consumptive-Use (ac-ft/yr)	Percent Consumptive Use	Estimation method / Notes
Total permitted yield Wyoming[a]	481,557	no estimate		Total permitted yield through 02/27/12 (See Table 8-6)
	277,010	no estimate		Permitted yield for likely existing wells through 02/27/12 (See Table 8-6)
Total permitted yield Wyoming, Idaho	[a,b] 499,640	no estimate		6,161 WSEO permits as of 02/27/12 89 IDWR permits as of 09/20/12 (See Tables 8-6, 8-7, 8-8)
Estimated withdrawals and consumptive uses of groundwater in Wyoming for agricultural, industrial, public and rural domestic water supplies and recreation.	14,600	8,600	58.9%	Pro-rated from 2002 and projected 2032 estimates in 2003 Snake/Salt River Basin Water Plan [c] normal demand/mid growth scenario Technical Memorandum V, Exhibits 6 and 7.
	No estimate	9,761	N/A	Estimated total groundwater use for 2012 made by WWDO for the Snake/Salt River Basin Water Plan
	No estimate	9,700	N/A	Totals of high use estimates from Tables 8-1a, 8-1b, 8-1c and 8-1d.

[a] Wyoming State Engineer's Office (2012)
[b] Idaho Department of Water Resources (2012)
[c] Sunrise Engineering (2003)
[d] WWDO, 2014

and gas operations in the Snake/Salt River Basin during the 2002 -2013 period of record.

Table 8-1c estimates combined municipal and domestic groundwater withdrawals and consumptive uses . The ranges of consumptive uses, shown and aggregated with other uses in **table 8-1f**, are compiled from Technical Memorandum V (BBC Research and Consulting, 2002) of the 2003 Snake/Salt River Basin Water Plan (Sunrise Engineering, 2003) and from the 2012 Snake/Salt River Basin Water Plan (WWDO, 2014). All municipal and rural domestic water demands are supplied by groundwater (BBC Research and Consulting, 2002; WWDO, 2014).

Table 8-1d shows recreational consumptive uses of groundwater from Technical Memorandum V (BBC Research and Consulting, 2002) of the 2003 Snake/Salt River Basin Water Plan (Sunrise Engineering, 2003)**.**

Table 8-1e contains SEO permitted withdrawal information for several "minor uses" - monitoring, other, and multi-use wells.

Table 8-1f: Total groundwater withdrawal and consumptive use estimates are shown for principal listed uses from the SEO and the Idaho Department of Water Resources (IDWR). Values obtained from **tables 8-1a** through **8-1d** were compiled from Technical Memorandum V (BBC Research and Consulting, 2002) of the 2003 Snake/Salt River Basin Water Plan (Sunrise Engineering, 2003).

8.3 Basinwide water balance

Tables 8-2a and **8-2b** contain mass balance, water budget calculations for the Wyoming portion of the Snake/Salt River Basin. The primary objective of the water balance analysis is to provide an estimate of basinwide evapotranspiration. In the process, withdrawal, consumptive use, and recharge data from this and other chapters in this report are conveniently compiled into one table (**table 8.2**). Armed with these estimates, first order approximations can be made of the proportions of precipitation destined for recharge, evapotranspiration, surface water outflows, and consumptive uses from water resource development.

The analysis contained in **table 8-2a** was adapted from the general water budget equation (Fetter, 2001):
Evapotranspiration = (precipitation + surface inflow + imported water + groundwater inflow) – (surface water outflow + groundwater outflow + reservoir evaporation + exported water + recharge) ± changes in surface water storage ± changes in groundwater storage

The assumptions used in this water balance are:

- Water is neither imported nor exported into or from the Snake/Salt River Basin.
- Basin groundwater inflows and outflows equal zero.
- Groundwater and surface water depletions are limited to consumptive uses from the municipal/domestic, livestock, and industrial sectors (i.e., SEO permitted uses).
- The water budget mass balance model examines annual fluxes of water resources in the Snake River Basin. Therefore, it is assumed that long term changes in stored surface and groundwater equal zero.

8.3.1 Precipitation

Precipitation is the ultimate source of groundwater recharge. Average annual precipitation volume in the Snake/Salt River Basin for the 30-year period of record (POR) from 1981 to 2010 was calculated using GIS software and PRISM data (http://prism.oregonstate.edu/ - **fig. 3-3**) at 9,137,300 ac-ft.

8.3.2 Surface water inflows and outflows

Average annual stream inflow and outflow data for the Wyoming portion of the basin were obtained from the USGS (http://water.usgs.gov/). Only USGS streamflow gaging station 13025500 on Crow Creek near Fairview, Wyoming monitors inflows from the small streams that enter Wyoming from tributaries in Idaho. Annual outflow data

Table 8-2a. Snake/Salt River Basin water resources mass balance.

WATER BALANCE PARAMETERS[a]		Average Annual Volume (ac-ft)
Precipitation (1981 - 2010 - Figure 3-3)[b]		9,137,300
Total surface water inflows[c]	+	43,700
Total surface water outflows[c]	-	4,643,100
Evaporation from reservoirs[d]:	-	72,200
Surface water and groundwater depletions from municipal/domestic, livestock, and industrial uses[d]	-	9,800
Total estimated Snake/Salt River Basin recharge (Table 6-3)	-	1,706,300
Basin-wide evapotranspiration	=	2,749,600

Comparative estimates

Estimated evapotranspiration in the Snake/Salt River Basin from the USGS climate and land-cover data regression[e] .

Total evapotranspiration 4,150,900 acre-feet

[a] Fetter , C. W., 2001
[b] PRISM Climate Group, 2012
[c] USGS, 2014
[d] Wyoming Water Development Office, 2014
[e] Sanford and Selnick, 2013

Table 8-2b. Estimated recharge and total evapotranspiration levels in the Wyoming portion of the Snake/Salt River Basin.

WATER BALANCE PARAMETERS[a]	% of Precipitation [b]
Net stream outflows[c]	50.10%
Evaporation from reservoirs[d]:	0.80%
Surface water and groundwater depletions from municipal/domestic, livestock, and industrial uses[d]	0.10%
Total estimated Snake/Salt River Basin recharge (Table 6-3)	19.00%
Basin-wide evapotranspiration	30.00%
Total	100.00%

[a] Fetter , C. W., 2001
[b] PRISM Climate Group, 2012
[c] USGS, 2014
[d] Wyoming Water Development Office, 2014

were recovered from USGS stream gaging stations 13022500, 13023000, 13046995, and 13027500. These stations are all sited on effluent reaches of the Snake, Salt, Falls, and Greys rivers near Wyoming's border with Idaho.

8.3.3 Evaporation from reservoirs

Evaporation data from the basin's reservoirs were obtained from Technical Memorandum XII of the 2012 Snake/Salt River Basin Water Plan (WWDO, 2014).

8.3.4 Depletions from municipal/ domestic, livestock, and industrial uses)

Surface water and groundwater depletions from municipal/domestic, livestock, and industrial uses were obtained from the 2012 Snake/Salt River Basin Water Plan (WWDO, 2014). Agricultural uses were not considered since 99.9 percent of irrigation water is lost to evapotranspiration, and return flows that recharge underlying aquifers or discharge to surface water bodies (Colorado State University, 2013).

8.3.5 Total estimated Snake/Salt River Basin recharge

The recharge value shown is the "best total recharge" estimate for sedimentary aquifers calculated on **tables 6-2** and **6-3** from the recharge fraction data in Hamerlinck and Arneson (1998) and PRISM (2013) precipitation data for the 1981 – 2010 period of record (POR).

8.3.6 Estimated basin-wide evapotranspiration

The water balance model adapted from Fetter (2001) and presented in **table 8-2a** places basin-wide evapotranspiration at 2,749,600 ac –ft per year. For comparison, a second estimate of actual evapotranspiration (4,150,900 ac-ft per year) in the Snake/Salt River Basin is shown at the bottom of **table 8-2a**. This estimate was obtained using a GIS based regression model developed by the USGS (Sanford and Selnick, 2013) from climate and land-cover data. The calculated results of the two methods in the Snake/Salt River Basin do not produce the close agreement previously seen in identical analyses conducted for the more arid Bear (Taboga and others, 2014) and Platte River basins (Taucher and others, 2013). The large discrepancy between the two estimates (1,401,300 ac-ft, or 51 percent) suggests that a significant portion of recharge in the semi-humid Snake/Salt River may return to streamflows in the form of baseflow. This premise is further supported by the potentiometric surface shown in **figure 7-3** that indicates that groundwater flows from Quaternary units to the Snake River.

8.4 Magnitude, origin, and fate of water resources in the Snake/Salt River Basin

Table 8-2b shows that approximately 30 percent of precipitation is lost to evapotranspiration in the Snake/Salt River Basin, about 19 percent recharges the basin's aquifers, and nearly 50 percent leaves as stream outflow. Evaporation from reservoirs constitutes about 0.8 percent of total basin precipitation. Combined surface water and groundwater depletions from municipal/domestic, livestock, and industrial uses comprise 0.1 percent of precipitation.

Table 8-2c summarizes various average groundwater consumptive use estimates from **tables 8-1a** through **8-1d** as percentages of estimated recharge. Aggregated municipal and domestic consumptive uses constitute about 0.5 percent of recharge. Estimated total annual consumptive uses (9,700 ac-ft **- table 8-1e**) constitute about 0.6 percent of annual average recharge.

Estimated recharge (**table 8-2c**) far exceeds average annual withdrawals of groundwater. Estimates of total average annual groundwater use could be substantially higher, and the estimates of recharge substantially lower, without significantly changing these simple, comparative results.

Table 8-2d evaluates future groundwater requirements relative to recharge. The 2012 Snake/Salt River Basin Water Plan (WWDO,

Table 8-2c. Summary of groundwater use statistics as percentage of recharge in the Wyoming portion of the Snake/ Salt River Basin.

Groundwater-use statistics	Annual volume (acre-feet)	Percentage of calculated recharge
[1]Estimated recharge (acre-feet) to sedimentary aquifers	1,706,300	-----
[3]Average annual groundwater consumptive uses		
[2] Agricutural uses (irrigation and stock watering)	700	0.04%
[2]Municipal & domestic	8,850	0.52%
[2]Industrial	0	0.00%
[2]Recreational	150	0.01%
[2]TOTAL	9,700	0.57%

[1]Table 8-2b
[2]Tables 8-1a-d
[3]Table 8-1f

Table 8-2d. Summary of future groundwater requirements as percentages of recharge.

Economic scenario	***Low growth***	***Mid growth***	***High growth***
Groundwater demand - 2032 consumptive use (acre-feet)	9,363	10,832	13,071
Percentage of estimated recharge	0.5%	0.6%	0.8%

[a] WWDC, 2012

2014) provides use factor-based projections of total, combined, annual withdrawals and consumptive uses for agricultural, municipal/ rural domestic, recreational, and industrial uses in 2032. The analysis examines normal and maximum water demand for low, moderate, and high economic growth scenarios. Projected future annual groundwater requirements for the 20-year timeframe are determined as percentages of annual recharge estimated in **chapter 6**.

Overall, groundwater consumptive uses projected for 2032 range from 0.5 percent of recharge for the low growth to 0.8 percent for the high growth scenario. Estimated recharge volumes are likely adequate to meet not only current withdrawals (**table 8-2c**) but future groundwater demands, as well. The potential for overutilization is location-specific, both hydrologically and legally, and must be evaluated during the planning stage of any development project. Evaluating potential groundwater resources of the Snake/Salt River Basin outside of existing environmental regulations and legal restrictions is beyond the scope of this study.

The following sections discuss the uses that account for nearly all estimated groundwater withdrawals in the 2003 Snake/Salt River Basin Water Plan (Sunrise Engineering, 2003) and the 2007 Statewide Framework Water Plan (WWC Engineering and others, 2007). **Tables 8-6** through **8-8** show the number of groundwater permits by use for the portions of Wyoming and

Idaho, respectively. The "other" category includes miscellaneous wells.

8.4.1 Agricultural uses (aggregated irrigation, livestock watering, and dairy)

Irrigation, livestock watering, and dairy uses were aggregated as agricultural uses in the 2003 Snake/Salt River Basin Water Plan (Sunrise Engineering and others, 2003). Direct measurements of groundwater volumes used for irrigation are not presented in the 2003 Snake/Salt River Basin report (Sunrise Engineering, 2003), in the 2007 State Framework Water Plan (WWC Engineering and others, 2007), or in the 2012 Snake/Salt River Basin report (WWDO, 2014). Instead, irrigation consumptive uses were calculated on actual crop-specific consumptive uses delimited/defined in Pochop and others (1992) and applied to crop distribution data obtained from the agricultural industry in the Snake/Salt River Basin. From these, total diversions and consumptive uses were generated for six cases formulated for low, moderate, and high economic growth scenarios within the context of both normal and maximum water demand conditions determined for the year 2002 (Sunrise Engineering, 2003). The same procedure was used to predict total irrigation diversions and consumptive uses for the year 2032. The Sunrise Engineering, (2003) study estimated the proportions of groundwater and surface water that constitute total withdrawals and consumptive use for all evaluated uses.

In the Snake/Salt River Basin, most irrigation wells are located along the river and its tributaries where water is obtained from relatively shallow alluvial deposits. Irrigation uses are largely consumptive due to evapotranspiration. Within the Snake/Salt River Basin, 57 SEO and one IDWR permits have been issued solely for irrigation use. Updated data for total permits and permitted yields from the SEO and IDWR are shown in **tables 8-6** and **8-7** and in **figure 8-1.**

Withdrawals and consumptive uses for livestock watering were calculated in the 2003 Water Plan (Sunrise Engineering, 2003) using stock-specific daily water requirements of 12 gal/day/animal for cattle and 2 gal/day/animal for sheep. It was assumed that all of the water used for livestock watering is consumptively used. In the Snake/Salt River Basin, 211 SEO permits and two IDWR permits have been issued solely for stock watering (**tables 8-6** and **8-7**).

8.4.2 Municipal/water systems (aggregated municipal/rural domestic water systems)

Municipal and rural domestic water systems were aggregated as municipal/water systems in the 2003 and 2012 Water Plans (Sunrise Engineering, 2003; WWDO, 2014). Municipal/rural water systems (http://www2.epa.gov/region8-waterops) supply water year-round to essentially the same population. Information for municipal water systems was obtained directly from water system operators and administrators in Afton, Alpine, Thayne, and Jackson. Average and peak use volumes for unincorporated communities were calculated by multiplying per capita values obtained from the documented municipal systems (Afton, Alpine, Thayne, and Jackson) by the population served.

Municipal/water systems use constitutes the majority of overall groundwater consumptive uses in the Snake/Salt River Basin (**table 8-2c**). As of February 27, 2012, the SEO issued 21 permits for exclusive municipal use and 3,751 domestic use permits in the Snake/Salt River Basin (**table 8-6**). IDWR has issued 48 domestic use permits in the Snake/Salt River Basin (**table 8-7**). In addition to the municipal use permits, some of the wells that supply water to the basin's municipalities and communities (**tables 8-8** through **8-10**) are permitted as multiple use or miscellaneous wells.

8.4.3 Recreational and environmental uses

In the Snake/Salt River Basin recreational water consumptive use is associated with snow making at ski resorts and turf irrigation at golf courses. Only a few recreational uses, such as snowmaking and turf irrigation, are consumptive. Based on prorated

levels of use from the Snake/Salt River Basin 2003 Water Plan (Sunrise Engineering, 2003), it is estimated that about 150 ac-ft is used for the recreation sector, which is expected to grow of 50 percent by 2032 (**table 8-2c**).

8.4.4 Industrial uses

The 2003 Water Plan (Sunrise Engineering, 2003) identified only three industrial water users in the basin and determined that industrial water use was about 130 acre-feet/year. Currently, operations have ceased at all three businesses (WWDO, 2014), and there is negligible industrial water use (**table 8-1b**) in the Snake/Salt River Basin. Permitted yields for SEO industrial permits are provided on **table 8-1b** for the reader's information.

8.5 Information from hydrogeologic unit studies

In addition to the withdrawal and consumptive use data compiled from previous state water plans, aquifer-specific groundwater use information was compiled from a variety sources for the **chapter 7** discussion of hydrogeologic units in the Snake/Salt River Basin. **Chapter 7** summarizes the physical, hydrogeologic, and chemical characteristics of the principal hydrogeologic units in the Snake/Salt River Basin including the known dynamics of recharge, discharge, and groundwater circulation.

Appendix B provides a chronological summary of the locations, aquifers, focus, results, and status of groundwater development studies that have been sponsored by the WWDC since 1973 in the Snake/Salt River Basin. Many of these studies were used to compile the information presented in **chapter 7**.

8.6 Groundwater permit information

Groundwater development proceeds primarily by installing water supply wells and, to a lesser degree, by developing natural springs. Permits allowing the appropriation of groundwater are issued and administered by the SEO in Wyoming and the Department of Water Resources (IDWR) in Idaho. For this study, the WSGS acquired groundwater permit data from both agencies. The SEO provided information for 6,161 groundwater permits through February 27, 2012, including 1,541 newer permits issued after December 31, 2003 (**table 8-6**). IDWR provided data for 89 Idaho groundwater permits through September 20, 2012. Limitations and other characteristics of the groundwater-permits databases are described in **appendix C.** Information for specific SEO groundwater permits can be accessed through the SEO online water rights database at: http://seo.state.wy.us/wrdb/PS_WellLocation.aspx. The database is easy to use and specific information can be queried using various search parameters (e.g., permit number, location, applicant, use).

Information on specific groundwater permits from the IDWR can be accessed at: http://www.idwr.idaho.gov/WaterManagement/default.htm.

Permits to appropriate groundwater in the Snake/Salt River Basin have been mapped for this study and certain data has been tabulated in formats that are highly informative. The maps of permit locations by use contained in **chapter 8** illustrate the spatial distribution of particular types of groundwater wells throughout the Snake/Salt River Basin. Groundwater permit data is tabulated in this section to summarize the number of permits by:

1. SEO permit status, depth range, and yield range;
2. Class of use (SEO, IDWR);
3. SEO municipal use, including producing hydrogeologic unit;
4. WDEQ Source Water Assessment Program (SWAP).

In addition, permit data are tabulated on maps depicting locations of likely drilled wells **(figs. 8-1** through **8-7**). SEO data are tabulated and mapped in this study for all permits through February 2012 and for permits from 2003 through February 2012 to illustrate development over the last decade.

8.6.1 Groundwater permits by permit status

Table 8-3 shows the number of groundwater permits issued by the SEO under five permit-status categories. **Table 8-3** does not include permits from the IDWR. In Wyoming, the status categories are:

1. *Fully Adjudicated* – the well has been drilled and inspected, and a certificate of appropriation issued.
2. *Complete* – SEO has received a notice of completion of the well.
3. *Unadjudicated* – the well has not yet been inspected but may have been drilled.
4. *Incomplete* – SEO has not received a notice of completion of the well.
5. *Undefined* – a permit without a designated status. These include the following discontinued status categories:
   - *Abandoned* – SEO has received a notice that the well has been physically abandoned.
   - *Expired* – the permit to appropriate groundwater has expired, generally because SEO has not received a notice that the well has been completed within the time period specified in the original permit or extension(s).
   - *Cancelled* – the permit has been cancelled, generally by the original permit applicant.

The SEO issues permits granting water rights to applicants. This does not necessarily mean that a well has been completed and in most cases, it is not known with any certainty whether a well was installed in association with a specific permit. To estimate the number of wells that have likely been completed for each use, the WSGS assumed that wells probably have been completed for fully adjudicated, complete, abandoned and unadjudicated permits. In contrast, wells are likely not completed in association with incomplete and undefined permits. **Table 8-3** summarizes the number of likely drilled wells for each use in the Snake/Salt River Basin. Based on these assumptions, at least 96 percent of wells permitted through 2003 are likely to have been installed (i.e., completed) compared to at least 74 percent of wells permitted since 2003.

8.6.2 Groundwater permits by depth and yield

Table 8-4 shows the number of permits by depth range, and **table 8-5** shows the number of permits by yield range. **Tables 8-4** and **8-5** do not include permits from the IDWR.

Table 8-3. SEO groundwater permits in the Snake/Salt River Basin listed by permit status.

Permit Status	All Permits through 2003	New Permits since 2003
Fully Adjudicated	248	28
Complete	3,950	638
Unadjudicated	4	65
Incomplete	221	408
Undefined	197	402
Total Permits	4,620	1,541
Probable Wells Drilled	4,423 - 4,620 (96 - 100%)	1,139 - 1,541 (74 - 100%)

Approximately 99.9 percent of all SEO groundwater permits for which depth data are available are for wells less than 500 feet deep, and approximately 87 percent are for wells less than 100 feet deep. All but four SEO groundwater permits issued from 2003 through February 2012 were for wells less than 500 feet deep, and approximately 82 percent were for wells less than 100 feet deep. In the SEO database, many of the permits (53 percent issued after 2003 and 19 percent overall) do not include well depth. Of the 5,287 groundwater permits in the Snake/Salt River Basin database for which yield information is available, approximately 85 percent of all permits and 70 percent of wells permitted since 2003 are allowed yields of 0-25 percent. Less than two percent of permits issued both since 2003 and in total are for yields greater than 1,000 gpm. Approximately seven percent of all permits and thirteen percent of permits issued after 2003 allow yields greater than 100 gpm. Many of the permits (11 percent issued after 2003 and 14 percent overall) in the SEO database do not include permitted yield.

Permitted depths and yields, and the mapped permit locations on **figures 8-1** through **8-7** illustrate that most wells in the Snake/Salt River Basin are planned and completed in near-surface, Quaternary hydrogeologic units.

8.6.3 Groundwater permits by use: tables, figures, and matrix tables

Groundwater permit information, by use, is presented in **tables 8-6** and **8-7** and **figures 8-1** through **8-7**, and the matrix tables contained in the figures. This information was obtained from the SEO and the IDWR. Both of these agencies

Table 8-4. SEO groundwater permits in the Snake/Salt River Basin listed by depth range.

Depth Range(feet)	All Permits		Cumulative	
	Permits	Percentage	Permits	Percentage
1-50	3637	72.51%	3637	72.51%
51-100	725	14.45%	4362	86.96%
101-500	648	12.92%	5010	99.88%
501-1000	6	0.12%	5016	100.00%
> 1000	0	0.00%	5016	100.00%
Total Permits with Depth information	5016	--	--	--
Permits with no Depth information	1145	18.58%	6161	--
Total Permits	6161	(of Total)	--	--

Depth Range(feet)	New Permits since 2003		Cumulative	
	Permits	Percentage	Permits	Percentage
1-50	479	65.62%	479	65.62%
51-100	119	16.30%	598	81.92%
101-500	128	17.53%	726	99.45%
501-1000	4	0.55%	730	100.00%
> 1000	0	0.00%	730	100.00%
Total Permits with Depth information	730	--	--	--
Permits with no Depth information	811	52.63%	1541	--
Total Permits	1541	(of Total)	--	--

Table 8-5. SEO groundwater permits in the Snake/Salt River Basin listed by yield range.

	All Permits		Cumulative	
Yield Range(gpm)	Permits	Percentage	Permits	Percentage
1-25	4516	85.42%	4516	85.42%
26-100	412	7.79%	4928	93.21%
101-500	246	4.65%	5174	97.86%
501-1000	71	1.34%	5245	99.21%
> 1000	42	0.79%	5287	100.00%
Total Permits with Yield information	5287	--	--	--
Permits with no Yield information	874	14.19%	6161	--
Total Permits	6161	(of Total)	--	--

	New Permits since 2001		Cumulative	
Yield Range(gpm)	Permits	Percentage	Permits	Percentage
1-25	960	69.72%	960	69.72%
26-100	241	17.50%	1201	87.22%
101-500	127	9.22%	1328	96.44%
501-1000	27	1.96%	1355	98.40%
> 1000	22	1.60%	1377	100.00%
Total Permits with Yield information	1377	--	--	--
Permits with no Yield information	164	10.64%	1541	--
Total Permits	1541	(of Total)	--	--

Table 8-6. SEO groundwater permits in the Snake/Salt River Basin listed by intended use.

Well Type	WSEO Code	Total Number of Permits	New Since 2001	Total Permitted Yield (gpm)	Total Likely Yield* (gpm)
Municipal	MUN	21	5	12,900	8,800
Domestic	DOM	3,751	763	68,719	60,067
Industrial	IND	7	2	820	495
Irrigation	IRR	57	13	19,293	7,350
Stock	STK	211	53	3,621	2,991
Monitor	MON	677	72	0	0
Other	MIS, blank	905	482	168,086	76,120
Multi-Use	various	532	151	27,533	17,308
Total		6,161	1,541	300,972	173,131

**Includes only wells that are Fully Adjudicated, Complete, and Unadjudicated.*

Table 8-7. Idaho DWR groundwater permits in the Snake/Salt River Basin listed by intended use.

Well Type	Total Number of Permits	New Since 2003	Total Permitted Yield (gpm)
Municipal	0	0	0
Domestic	48	18	10,763
Industrial	1	0	0
Irrigation	1	0	300
Stock	2	2	0
Monitoring	30	17	179
Other	6	1	25
Multi-use	1	0	35
Total	89	38	11,302

issue permits granting water rights to applicants. In many cases, especially with older permits, it is not known with any certainty whether a well or spring improvement was actually installed in association with a specific permit. Furthermore, existing facilities might have been abandoned after some time and are no longer being used beneficially. Any examination of permitted uses must explain how the permit data was processed and what it actually represents. The permit data presented in the following two sections differs between the figures and the tables:

- **Tables 8-6** and **8-7** show the number of groundwater permits issued in Wyoming and Idaho, respectively, by permitted use regardless of permit status (**section 8.4.1**). This means that all permits issued are listed without evaluating if a well was installed. The tables list six single primary use categories (municipal, domestic, industrial, irrigation, stock, and monitoring), an "other" category for all other single uses, and a "multi-use" category for permits that list more than one use (approximately 8 percent of all groundwater permits in the Snake/Salt River Basin are for multiple uses). The "other" category includes permits issued for "miscellaneous uses" and for minor uses, such as test wells. The number of permits given for a single use (e.g., 21 total permits for municipal use in **table 8-6**) includes neither "multi-use" permits which may allow municipal use in addition to other uses nor those permits listed as "other" which may allow municipal withdrawals. Additionally, values for "total permitted yield" calculated by summation of all permits with listed yields and "total likely yield" determined by analysis of permit status are provided.

- **Figures 8-1** through **8-7** show the number of "likely drilled wells", determined by analysis of permit status (**section 8.4.1**) for each of the six primary use categories (municipal, domestic, industrial, irrigation, stock, and monitoring) and miscellaneous wells. This includes permits where one use is listed. For example, the number of municipal wells is determined by counting single use "municipal" wells and any "multi-use" permits which include "municipal" as one of the permitted uses. Thus, multi-use wells are counted several times, once for each listed use.

- Matrix tables contained in each of the figures, present the number of all permits issued for each use combined in both states (**fig. 3-1**) regardless of permit status. This includes permits where one use is listed, for example "municipal" as well as "multi-use" permits which include "municipal" as one of the permitted uses.

8.6.3.1 Groundwater permits by use: Tables 8-6 through 8-10

Tables 8-6 and **8-7** show that most groundwater permits in the Snake/Salt River Basin are for domestic use at individual residences, followed by wells categorized as "other" and designated for monitoring.

Additionally, total likely yields (permitted yields from wells that are likely to be completed) constitute a fraction of the total permitted yields. A comparison of total likely yields to total permitted yields for each use suggests that a higher proportion of domestic and stock wells were completed and used beneficially than other type of wells.

Tables 8-8 and **8-9** are expanded summary tables for SEO permits that include municipal uses, and **table 8-10** summarizes information on SWAP wells and springs that are used for both municipal and non-community public water supply. A brief discussion of the SWAP is provided in **section 8.4.3.7**. The SWAP provides some information beyond what is available in the SEO groundwater permits data.

8.6.3.2 Groundwater permit location maps and matrix tables, by use

Seven maps (**figs. 8-1** through **8-7**) were prepared for this study to illustrate the geospatial distribution of groundwater permits according to use in the Snake/Salt River Basin. Only permits for wells that were likely to have been drilled (including abandoned wells) are included on **figures 8-1** through **8-7.** Groundwater permits are mapped relative to their date of issue (before or after January 1, 2003) on Snake/Salt River Basin scale maps and by total well depths on subregion scale figures. Figures have been provided for the following permitted uses:

- Irrigation (**fig**. **8-1**)
- Livestock (**fig**. **8-2**)
- Municipal (**fig**. **8-3**)
- Domestic (**fig**. **8-4**)
- Monitoring (**fig**. **8-5**)
- Miscellaneous-use and other wells (**fig**. **8-6**)
- Industrial-use wells (**fig**. **8-7**)
- USGS spring locations are shown on **figure 7-2**

Figures 8-1 through **8-7** differentiate groundwater permits issued from January 1, 2003 through February 27, 2012 in order to evaluate how groundwater development in the Snake/Salt River Basin has proceeded during the past decade. Substantial groundwater development has occurred in the Snake/Salt River Basin since the 2003 Groundwater Determination (Sunrise Engineering, 2003). Consistent with the historic trend, it is clear that most permits issued over the 2003 - 2012 period of record in the Snake/Salt River Basin continue to target Quaternary and Tertiary hydrogeologic units.

Matrix tables that correlate ranges of well depths and yields for all permits issued are also provided on the groundwater permit maps. Consistent with **tables 8-4** and **8-5**, the depth vs. yield tables shows that by far the most permits issued in the Snake/Salt River Basin are for 0-25 gpm across all depth ranges. In addition, the insert tables show that fewer wells are permitted for increasingly higher yields across all depth ranges. Because only permits for wells that were likely to have been drilled (status of fully adjudicated, complete, unadjudicated, and abandoned) are shown on **figures 8-1** through **8-7**, the number of permits on the insert matrix tables does not match the number of permits depicted on the maps.

Figure 5-10 shows the distribution of SWAP wells that are used for municipal and other public supply. Because public supply is one of the most important uses of groundwater resources, a more comprehensive compilation was performed for the SEO permit data and related WDEQ SWAP data on municipal and non-community public groundwater supplies.

8.6.3.3 Irrigation use permits

Tables 8-6 and **8-7** list 58 groundwater permits for irrigation use (IRR) in the Snake/Salt River Basin, with 57 in Wyoming and one in Idaho. **Figure 8-1** shows the distribution of likely drilled irrigation wells in the entire Snake/Salt River Basin, issued

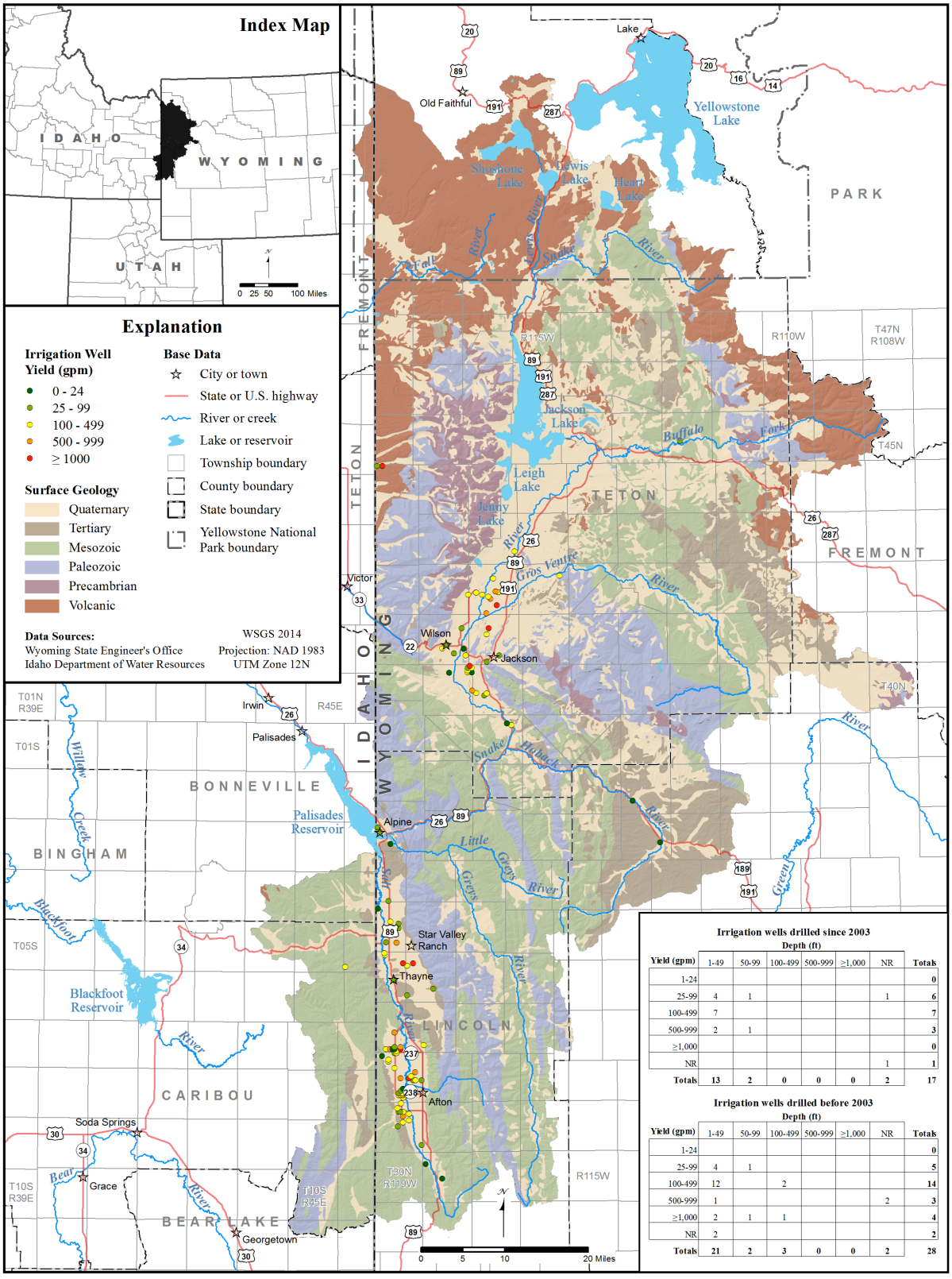

Figure 8-1. Wyoming SEO and Idaho DWR permitted and drilled irrigation wells, Snake/Salt River Basin.

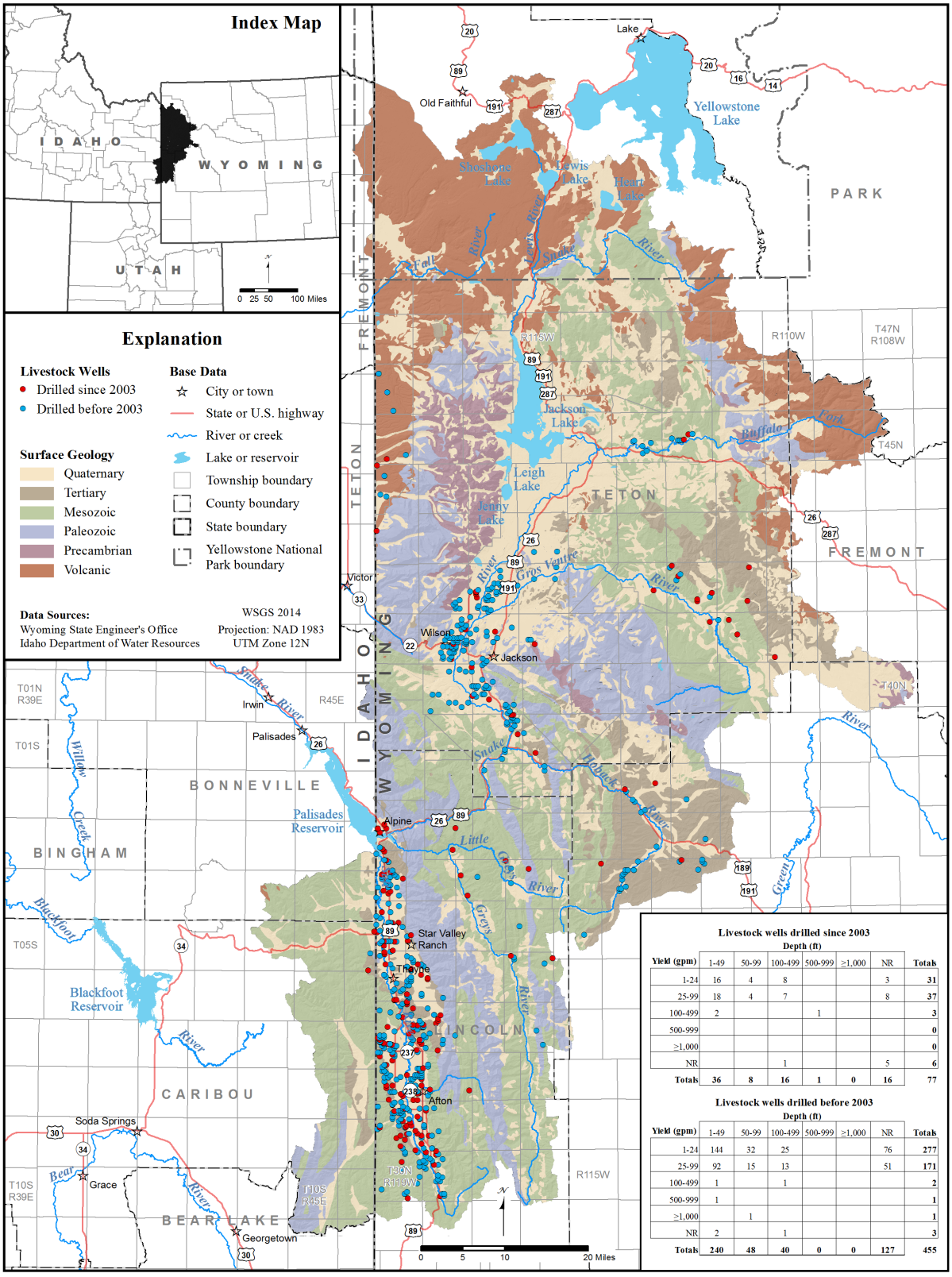

Figure 8-2. Wyoming SEO and Idaho DWR permitted and drilled livestock wells, Snake/Salt River Basin.

before and after January 2003. Most irrigation wells are located in rural areas and along rivers and other surface drainages where Quaternary hydrogeologic units provide adequate groundwater for this high-volume use. The depth vs. yield tables on **figure 8-1** show that while permits have been issued for all depth categories, most irrigation well permits that list depth were permitted for depths of less than fifty feet, across a wide range of yields for both total permits and permits issued since January 2003. **Tables 8-6** and **8-7** and the matrix tables in **figure 8-1** illustrate that most irrigation permits in the Snake/Salt River Basin were issued before 2003. **Figure 8-1** illustrates that most permits appropriate water from wells located near the Snake/Salt River, likely targeting alluvial deposits adjacent to the river.

8.6.3.4 Livestock use permits

Tables 8-6 and **8-7** show that 211 SEO permits and two IDWR groundwater permits have been issued solely for livestock use (STK) in the Snake/Salt River Basin. **Figure 8-2** shows the distribution of likely drilled stock wells in the Snake/Salt River Basin issued before and after January 2003. Stock wells are located throughout the basin, especially along the Snake and Salt rivers and tributary streams. Although, most stock wells are completed in Quaternary hydrogeologic units, some are completed in outcrops of Tertiary to Mesozoic aquifers and confining units located in areas along the uplands. The depth vs. yield tables on **figure 8-2** show that the largest number of total permits and permits issued since 2003 are for depths of one hundred feet or less and for yields of up to one hundred gpm. Many permits for stock watering have no recorded depth information.

8.6.3.5 SEO Municipal use permits

Tables 8-6 and **8-7** show that all 21 groundwater permits issued solely for municipal use (MUN) in the Snake/Salt River Basin are located in Wyoming. **Figure 8-3** shows the spatial distribution of likely drilled municipal wells. Most municipal permits do contain depth data. No municipal-use permits were listed in the IDWR data.

Tables 8-8 and **8-9** distinguish 31 municipal use groundwater permits on file with the SEO by status. **Table 8-8** summarizes selected information on twenty municipal-use permits that have been fully adjudicated. **Table 8-8** includes available information on permitted yield, well depth, depth of the producing interval, and the producing hydrogeologic unit. Six of the permits in **table 8-8** are for multiple uses. Because the "fully adjudicated" permit status indicates that the well has been inspected, the information in **table 8-8** is presumed to be fairly accurate. The wells in **Table 8-8** produce water from alluvial and bedrock aquifers (**pl. 2**). Information on producing intervals was obtained from SWAP data, WWDC consultant reports, and SEO data.

Table 8-9 summarizes selected information on eleven SEO municipal well permits listed as incomplete or that do not have a status listed. **Table 8-9** includes available information on permitted yield and well depth. Four of the permits in **table 8-9** are for multiple uses. The wells in **table 8-9** produce water from alluvial and bedrock aquifers (**pl. 2**).

While cancelled permits may or may not be associated with a completed well, abandoned status generally refers to a previously existing well.

8.6.3.6 Domestic use permits

Domestic water withdrawals include non–community public water systems and rural domestic users. **Tables 8-6** and **8-7** show that groundwater permits for domestic use (DOM) outnumber permits for all other uses combined, with 3,751 SEO permits, and 48 IDWR permits.

Figure 8-4 shows the distribution of likely drilled domestic-use permits in the entire Snake/Salt River Basin issued before and after January 2003. Most domestic wells are located in rural areas, generally outlying population centers along rivers and other surface drainages. Most wells are completed in Quaternary and Tertiary geologic units. The depth vs. yield tables on **figure 8-4** show that basinwide, the largest percentage of permits issued before and since January 2003 allow well depths up to 499

Table 8-8. SEO fully adjudicated municipal well permits in the Snake/Salt River Basin.

Municipality or Community	Well Name	WSEO Permit Number	Permit yield (gpm)	Well Depth (feet)	Hydro-geologic unit	Multi-use	Depth of Producing Interval (feet)
Afton	AFTON WELL #1	P86364.0W	900	156	Salt Lake Formation		200-317
Afton	ENL AFTON WELL #1	P91531.0W	200	156			200-317
Alpine	ALPINE WATER DISTRICT #1	P39163.0W	200	60	Alluvium		180-265
Alpine	ALPINE WATER & SEWER DISTRICT WELL #2	P77717.0W	375	85.5	Alluvium		147-243
Alpine	ENL ALPINE WATER DISTRICT #1	P78067.0W	100	60			180-265
Alpine	ENL ALPINE WATER DISTRICT #1 WELL	P98662.0W	50	60			180-275
Jackson	JACKSON WELL #6	P101360.0W	1250	6.6	Alluvium/Colluvium	yes	7-81
Jackson	JACKSON WELL #7	P101361.0W	1250	5.8	Alluvium/Colluvium	yes	6-80
Jackson	JACKSON WELL #8	P101362.0W	1250	5.5	Alluvium/Colluvium	yes	6-81
Jackson	1ST ENL JACKSON WATER WELL #1	P104232.0W	0	54.5	Alluvium/Colluvium	yes	50-160
Jackson	3RD ENL JACKSON WATER WELL #2	P104233.0W	0	38.34	Alluvium/Colluvium	yes	60-165
Jackson	2ND ENL JACKSON WATER WELL #3	P104234.0W	0	27	Alluvium/Colluvium	yes	75-95
Jackson	JACKSON WATER WELL #1	P1385.0W	950	54.5			50-160
Jackson	JACKSON WATER WELL #2	P1386.0W	700	38.34			60-165
Jackson	JACKSON WATER WELL #3	P1945.0W	700	27			75-95
Jackson	ENL JACKSON WATER WELL #2	P2055.0W	950	38.34			60-165
Jackson	JACKSON #5	P69746.0W	2500	5			82-147
Jackson	ENL JACKSON WATER WELL #2	P85495.0W	100	45			185-195
Jackson	ENL JACKSON WATER WELL #3	P85496.0W	75	33			70-100
Thayne	THAYNE PHASE I WELL	P130958.0W	1000	27.7	Salt Lake Formation		28-310

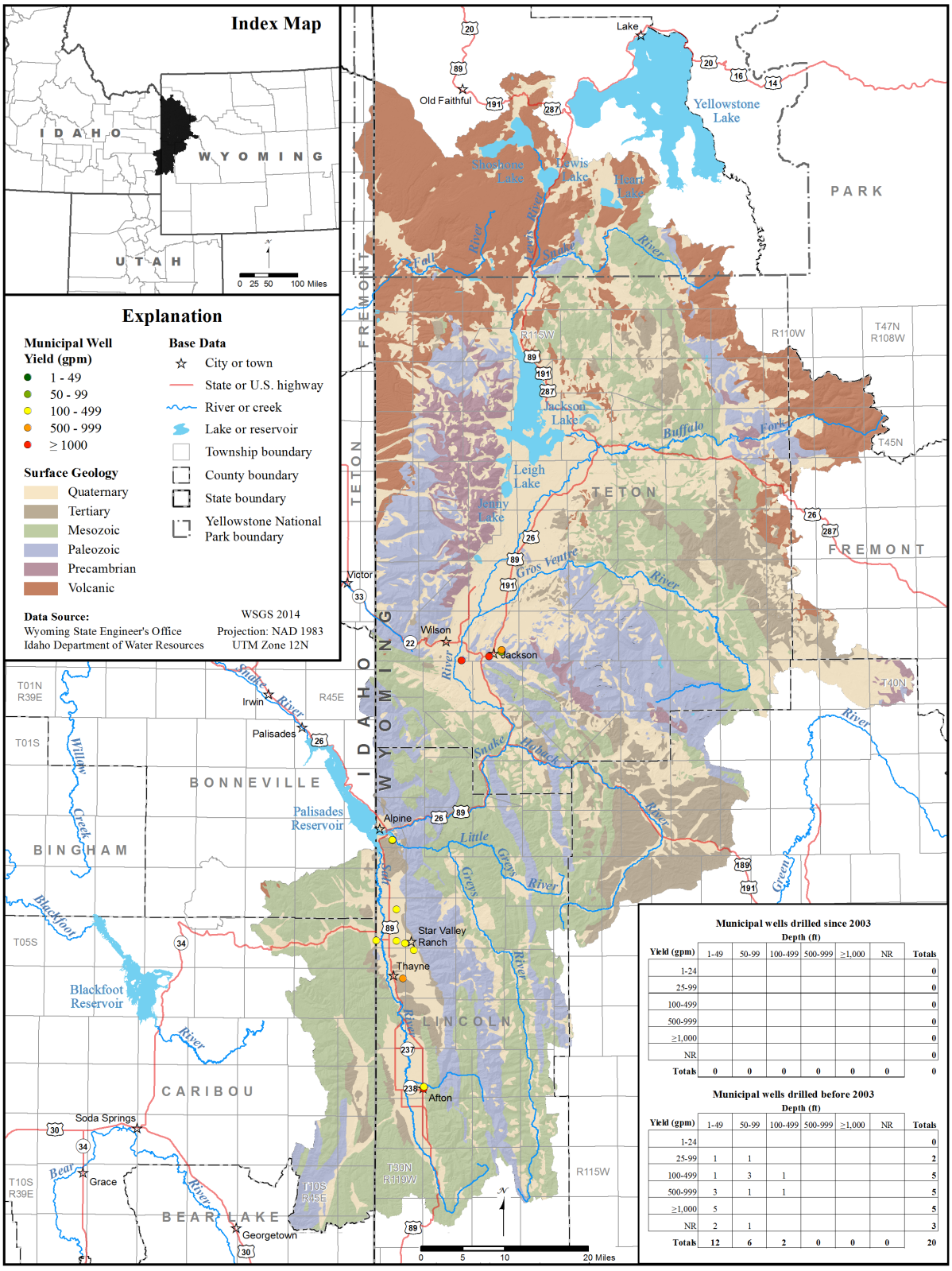

Figure 8-3. Wyoming SEO and Idaho DWR permitted and drilled municipal wells, Snake/Salt River Basin.

Table 8-9. Incomplete, cancelled, abandoned, and unlisted SEO municipal well permits in the Snake/Salt River Basin.

Municipality or Community	Well Name	WSEO Permit Number	Permit Yield (gpm)	Well Depth (feet)	Permit Status	New since 2005?	Multiple Use Well
Afton	AFTON EAST ALLEY WELL	P172886.0W	1200			Yes	
Alpine	3RD ENL ALPINE NO. 1 WELL	P189882.0W	350		Incomplete	Yes	
Alpine	1ST ENL ALPINE NO. 2 WELL	P189883.0W	325		Incomplete	Yes	
Etna	ETNA WELL NO. 1	P139351.0W	350	212	Incomplete		Yes
Freedom	FREEDOM #2	P101707.0W	400	67	Incomplete		Yes
Freedom	FREEDOM PIPELINE WELL #1	P396.0G	500	6	Incomplete		
Jackson	1ST ENL JACKSON WATER WELL #5	P104235.0W	0	5	Incomplete		Yes
Jackson	2ND ENL. JACKSON WATER WELL # 1	P142426.0W	500				Yes
Jackson	3RD ENL. JACKSON, TOWN OF	P146696.0W	925				
Star Valley Ranch	TSVR NO. 2	P193033.0W	300	178	Incomplete	Yes	
Star Valley Ranch	TSVR NO. 3	P193487.0W	500		Incomplete	Yes	

feet and yields up to 99 gpm. Many domestic use permits do not provide any recorded depth information.

8.6.3.7 Source Water Assessment Program (SWAP) wells and springs

The SWAP, a component of the federal Safe Drinking Water Act, is designed to help states protect public water systems (PWS) and applies to both municipal and non-community public systems. The voluntary program, administered by the WDEQ Water Quality Division (WQD), encourages the development of source-water assessments and Wellhead Protection Plans (WHP) for groundwater PWS. A source-water assessment entails determining the source-water contributing area, inventorying potential sources of contamination to the PWS, determining the susceptibility of the PWS to identified potential contaminants, and summarizing the information in a report. An important aspect of these reports relative to this study is that the producing hydrogeologic unit is commonly identified. As discussed in **section 5.7.4**, the individual PWS reports provide valuable information on recharge areas, resource vulnerability and local sources of potential contaminants for specific groundwater sources. The development and implementation of SWAP/WHP assessments and plans is ongoing throughout Wyoming. Additional information on the SWAP in Wyoming can be accessed at: http://deq.state.wy.us/wqd/www/SWPWHP/SWAP_FAQs.

Table 8-10 provides SEO water right permit number, yield, producing unit and depth data for 135 SWAP wells in the Snake/Salt River Basin. The SEO permit numbers shown can be correlated with the wells shown in **tables 8-9** and **8-10**. Although most wells in the SWAP database produce groundwater from alluvial deposits and Tertiary aquifers, volcanic, Cretaceous, and Paleozoic units are also identified as producing units in **table 8-10**. **Figure 5-11** shows the geospatial distribution of SWAP wells in the Snake/Salt River Basin and their relative susceptibility to potential contaminants.

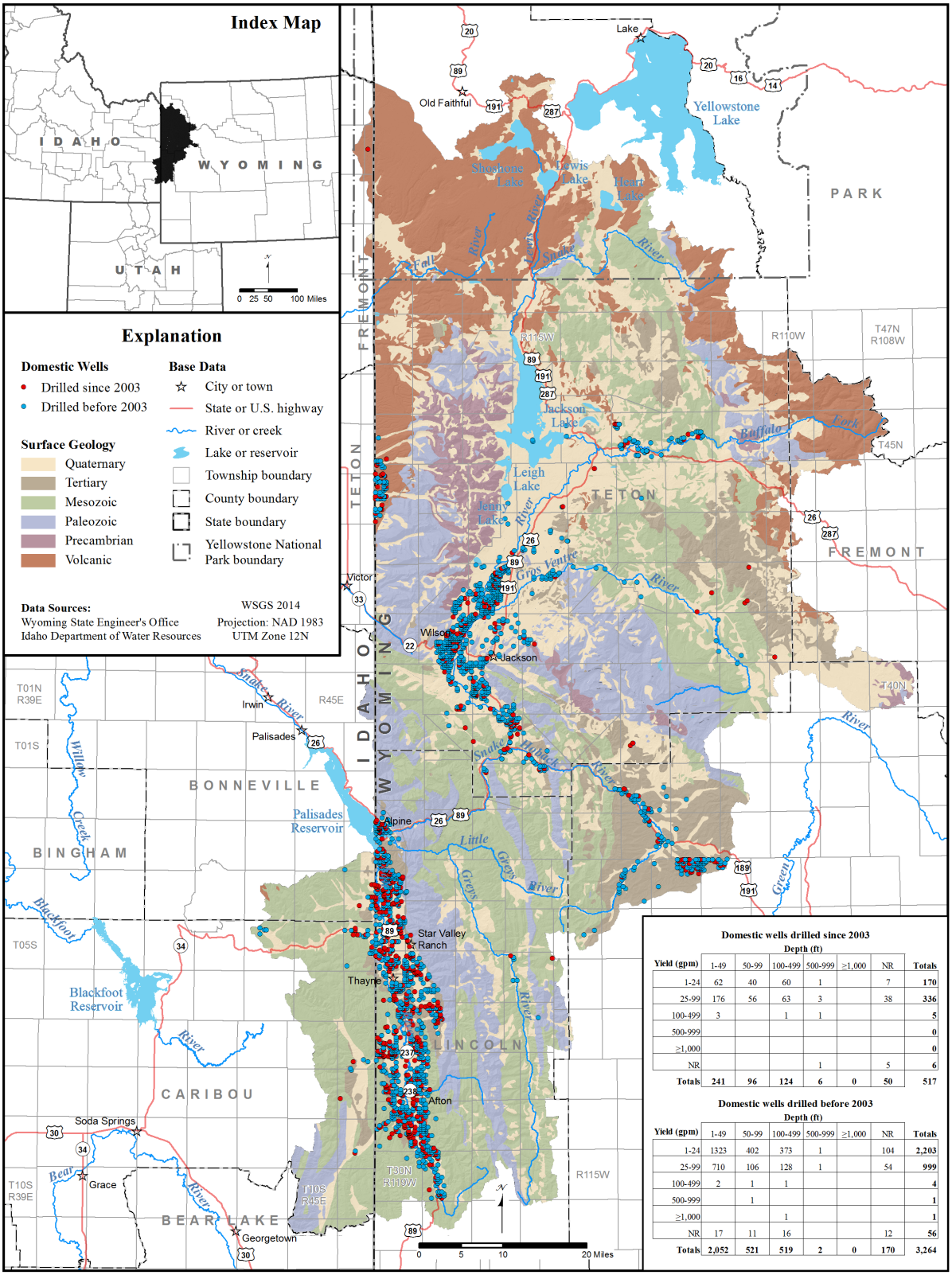

Figure 8-4. Wyoming SEO and Idaho DWR permitted and drilled domestic wells, Snake/Salt River Basin.

Table 8-10. WDEQ Source Water Assessment Program (SWAP) wells and springs used for municipal and non-community public water supply in the Snake/Salt River Basin.

MUNICIPALITY	Well Name	Public Water System ID	WSEO Permit No.	Well Depth (ft)	Source Type	Producing Unit
Town of Afton						
	AFTON, BOARD OF PUB UTILILTIES	5600002-102	P86364W	311	Well	Salt Lake Fm
	AFTON, BOARD OF PUB UTILILTIES	5600002-104		0	Well	Salt Lake Fm
	AFTON, BOARD OF PUB UTILILTIES	5600002-101	P7010E	0	Spring	Madison Limestone
	AFTON, BOARD OF PUB UTILILTIES	5600002-103	P65653W	126	Well	Salt Lake Fm
Town of Alpine						
	ALPINE, TOWN OF	5600156-101		0	Spring	Teewinot Fm
	ALPINE, TOWN OF	5600156-102	P77717W	243	Well	Alluvium
	ALPINE, TOWN OF	5600156-103	P39163W	275	Well	Alluvium
Town of Jackson						
	JACKSON, TOWN OF	5600213-105	P101360W	81	Well	Alluvium/ Colluvium
	JACKSON, TOWN OF	5600213-107	P101362W	81	Well	Alluvium/ Colluvium
	JACKSON, TOWN OF	5600213-106	P101361W	81	Well	Alluvium/ Colluvium
	JACKSON, TOWN OF	5600213-104	P104235W	147	Well	Alluvium/ Colluvium
	JACKSON, TOWN OF	5600213-101	P104232W	201	Well	Alluvium/ Colluvium
	JACKSON, TOWN OF	5600213-102	P104233W	200	Well	Alluvium/ Colluvium
	JACKSON, TOWN OF	5600213-103	P104234W	200	Well	Alluvium/ Colluvium
Wells without known Municipality						
	None listed	5601456-101	P65653W	0	Well	
	None listed	5600721-101	P11180W	20	Well	
	None listed	5600802-101	P54660	0	Well	
	None listed	5601253-101	P90673W	245	Well	Alluvium
	None listed	5680109-101	P26143W	101	Well	Alluvium
	None listed	5680117-101		36	Well	

Table 8-10. cont.

MUNICIPALITY	Well Name	Public Water System ID	WSEO Permit No.	Well Depth (ft)	Source Type	Producing Unit
	ASPENS WATER & SEWER DISTRICT	5600220-103		100	Well	Alluvium/ Colluvium
	ASPENS WATER & SEWER DISTRICT	5600220-104	P101920W	95	Well	Alluvium/ Colluvium
	ASPENS WATER & SEWER DISTRICT	5600220-102	P101921W	152	Well	Alluvium/ Colluvium
	ASPENS WATER & SEWER DISTRICT	5600220-101	P101923W	109	Well	Alluvium/ Colluvium
	BAR J CHUCKWAGON	5600886-101	P40479W	60	Well	
	BEDFORD WATER & SEWER DISTRICT	5600006-103	P81829W	350	Well	Salt Lake Fm
	BEDFORD WATER & SEWER DISTRICT	5600006-101		0	Spring	Bighorn Dolomite, Gallatin Limestone, Gros Ventre Fm and Flathead Sandstone
	BEDFORD WATER & SEWER DISTRICT	5600006-102		0	Spring	Bighorn Dolomite, Gallatin Limestone, Gros Ventre Fm and Flathead Sandstone
	BRIDGER-TETON NF ATHERTON CR	5680207-102	P65736W	105	Well	
	BRIDGER-TETON NF HOBACK CG	5680139-101	P19402	0	Well	
	BRIDGER-TETON NF TURPIN MEADOW	5680210-101	P71623W	135	Well	
	BUFFALO VALLEY WATER DISTRICT	5600435-101	P120244W	155	Well	Unnamed ss fm and Bacon Ridge ss
	BUFFALO VALLEY WATER DISTRICT	5600435-102	P77006W	93	Well	Unnamed ss fm and Bacon Ridge ss
	CONTINENTAL INVESTMENTS OF WY, LLC	5601258-101	P101733W	131	Well	Alluvium

MUNICIPALITY	Well Name	Public Water System ID	WSEO Permit No.	Well Depth (ft)	Source Type	Producing Unit
	COWBOY VILLAGE RESORT	5600501-102		250	Well	Glacial Deposits
	COWBOY VILLAGE RESORT	5600501-101		150	Well	Glacial Deposits
	COWBOY VILLAGE RESORT	5600501-103		0	Spring	Glacial Deposits
	COWBOY VILLAGE RESORT	5600501-104		0	Spring	Glacial Deposits
	COWBOY VILLAGE RESORT	5600501-105		0	Spring	Glacial Deposits
	COWBOY VILLAGE RESORT	5600501-106		0	Spring	Glacial Deposits

Table 8-10. cont.

MUNICIPALITY	Well Name	Public Water System ID	WSEO Permit No.	Well Depth (ft)	Source Type	Producing Unit
	C-V RANCHES (BOCES REG V)	5600806-101	P53100W	120	Well	Terrace
	C-V RANCHES (BOCES REG V)	5600806-102	P53848W	120	Well	Terrace
	DORNAN`S MOOSE ENTERPRISES	5601261-101	P89284W	85	Well	Terrace
	DORNAN`S MOOSE ENTERPRISES	5601261-102	P89286W	90	Well	Terrace
	ELK REFUGE INN	5600999-101		990	Well	Alluvium/ Colluvium
	ELKHORN BAR	5600528-101	P80633W	32	Well	
	ELKHORN BAR	5600528-103	P80633	32	Well	Madison Ls, Darby Fm, Bighorn Dolomite, Gallatin Ls, Gros Ventre Fm, Flathead Ss
	ETNA WATER & SEWER DISTRICT	5600157-101		0	Spring	Madison Ls, Darby Fm, Bighorn
	ETNA WATER & SEWER DISTRICT	5600157-102		0	Spring	Dolomite, Gallatin Ls, Gros Ventre Fm, Flathead Ss
	ETNA WATER & SEWER DISTRICT	5600157-103	P92269W	400	Well	Salt Lake Fm
	EVANS MOBILE HOME COURT	5600215-101	P20371W	70	Well	Snake River Alluvium
	EVANS MOBILE HOME COURT	5600215-102	P61731W	60	Well	Snake River Alluvium
	EVANS MOBILE HOME COURT	5600215-103	P42289W	75	Well	Snake River Alluvium
	FAIRVIEW WATER & SEWER DIST.	5600166-101	P93172W	418	Well	Salt Lake Fm
	FISH CREEK CENTER	5601412-101	P108620W	651	Well	Alluvium
	FISH CREEK INN	5600903-101	P29179W	58	Well	
	FLAT CREEK MOTEL	5601186-101	P76783	111	Well	Alluvium/ Colluvium
	FLAT CREEK RV PARK	5601273-101	P99707W	40	Well	
	FLYING SADDLE LODGE	5600604-101	P101241W	163	Well	
	FREEDOM WATER & SEWER DISTRICT	5600158-101	P396G	0	Well	
	GRAND TARGHEE RESORT	5601201-103	P40451W	700	Well	Madison Limestone
	GRAND TARGHEE RESORT	5601201-101	P3373W	676	Well	Madison Limestone
	GRAND TETON NP CLIMBERS RANCH	5680094-101		88	Well	terrace

Table 8-10. cont.

MUNICIPALITY	Well Name	Public Water System ID	WSEO Permit No.	Well Depth (ft)	Source Type	Producing Unit
	GRAND TETON NP COLTER BAY	5680095-102	P30080W	175	Well	terrace
	GRAND TETON NP COLTER BAY	5680095-101	P842W	201	Well	terrace
	GRAND TETON NP ENV ED CENTER	5680099-101		10	Well	Alluvium
	GRAND TETON NP FLAGG RANCH	5680097-102		100	Well	Terrace
	GRAND TETON NP FLAGG RANCH	5680097-101		95	Well	Glacial Deposits
	GRAND TETON NP GROS VENTRE CG	5680100-101	P1377W	150	Well	Terrace
	GRAND TETON NP HIGHLANDS	5680101-101	P26142W	151	Well	Terrace
	GRAND TETON NP JACKSON LK LDGE	5680103-101	P30080W	250	Well	terrace
	GRAND TETON NP JENNY LAKE CAB	5680156-101	P142C	150	Well	Terrace
	GRAND TETON NP JENNY LAKE LODG	5680157-101		376	Well	terrace
	GRAND TETON NP LEEKS LODGE	5680105-101		131	Well	Glacial Deposits
	GRAND TETON NP LIZARD CRK CG	5680106-101	P865W	101	Well	Newcastle Sandstone
	GRAND TETON NP MOOSE BEAVER CK	5680093-102	P130045W	160	Well	terrace
	GRAND TETON NP MOOSE BEAVER CK	5680093-101	P130046W	160	Well	terrace
	GRAND TETON NP MORAN BFLO RNGR	5680107-101	P149068W	38	Well	Terrace
	GRAND TETON NP S.JENNY LAKE WS	5680096-101	P141G	250	Well	terrace
	GRAND TETON NP SIGNAL MTN	5680108-101		260	Well	Glacial Deposits
	GRAND TETON NP TRIANGLE X RANC	5680110-101		0	Spring	Glacial Outwash
	GROS VENTRE GRILL	5601227-101	P22750W	33	Well	Alluvium/ Colluvium
	GROS VENTRE RIVER RANCH	5601406-101	P84656W	0	Well	

MUNICIPALITY	Well Name	Public Water System ID	WSEO Permit No.	Well Depth (ft)	Source Type	Producing Unit
	GROS VENTRE UTILITY	5600027-102	P76095W	151	Well	Terrace
	GROVER WATER & SEWER DISTRICT	5600160-101	P93173W	300	Well	Salt Lake Fm

Table 8-10. cont.

MUNICIPALITY	Well Name	Public Water System ID	WSEO Permit No.	Well Depth (ft)	Source Type	Producing Unit
	GROVER WATER & SEWER DISTRICT	5600160-102	P56049W	250	Well	Salt Lake Fm
	GROVER WATER & SEWER DISTRICT	5600160-103	P18543D	0	Spring	Nugget SS or Ankareh Fm
	HATCHET CAFE & MOTEL	5600517-103	P72854W	65	Well	
	HOBACK VILLAGE	5600695-101	P29305W	25	Well	Alluvium
	JACKSON HOLE AIRPORT	5600844-101	P86871W	143	Well	
	J-W SUBDIVISION	5600877-102	P77828W	260	Well	Bear River Fm
	J-W SUBDIVISION	5600877-103	P60074W	175	Well	Bear River Fm
	KENNINGTON SPRINGS PIPELINE	5601199-101		0	Spring	Stump fm, Preuss sandstone or redbeds and twin creek limestone
	LAZY J CORRAL	5600347-102	P82575W	95	Well	
	LAZY J CORRAL	5600347-101	P91530W	300	Well	
	LONE EAGLE RESORT	5601264-101	P104732W	500	Well	Bear River Fm
	LOWER VALLEY ENERGY	5601403-101	P52035W	360	Well	Alluvium
	MAVERICK STATION	5600882-101		0	Well	Alluvium
	MOUNTAIN INN MOTEL	5601150-101	P20372W	280	Well	Salt Lake Fm.
	NATIONAL WILDLIFE ART MUSEUM	5601325-101	P89598W	186	Well	
	NORDIC RANCHES PROPERTY ASSOC.	5601418-102	P108464W	550	Well	Bighorn Dolomite
	NORDIC RANCHES PROPERTY ASSOC.	5601418-101	P100147W	360	Well	Bighorn Dolomite
	NORTH ALPINE IMPROVEMENT & SERVICE DIST	5601021-101	P102467W	109	Well	
	OSMOND PIPELINE CO	5600154-101	P72735W	0	Spring	Nugget Sandstone
	R LAZY S RANCH	5600499-101	P71244W	63	Well	Terrace
	R LAZY S RANCH	5600499-102	P79922W	60	Well	Terrace
	RAFTER J SUBDIVISION HO ASSN	5600822-101	P93364W	100	Well	Alluvium/ Colluvium
	RAFTER J SUBDIVISION HO ASSN	5600822-102	P48096W	100	Well	Alluvium/ Colluvium
	SNAKE RIVER PARK, INC.	5600519-101	P51149W	100	Well	
	SO. PARK VILLAGE SUBD	5600836-101	P4842P	212	Well	Alluvium/ Colluvium

Table 8-10. cont.

MUNICIPALITY	Well Name	Public Water System ID	WSEO Permit No.	Well Depth (ft)	Source Type	Producing Unit
	SPOTTED HORSE RANCH	5600492-101		65	Well	Alluvium
	SPOTTED HORSE RANCH	5600492-102		65	Well	Alluvium
	SPOTTED HORSE RANCH	5600492-103		65	Well	Alluvium
	SPRING CREEK IMP DIST.	5600811-101	P96458W	123	Well	
	STAR VALLEY RANCH ASSOCIATION	5600287-104	P112167W	380	Well	Salt Lake Fm
	STAR VALLEY RANCH ASSOCIATION	5600287-103	P90328W	460	Well	Salt Lake Fm
	STAR VALLEY RANCH ASSOCIATION	5600287-102	P28134W	0	Spring	Bighorn Dolomite, Gallatin Limestone, Gros Ventre Fm, Flathead Sandstone
	STAR VALLEY RANCH ASSOCIATION	5600287-101	P112130W	0	Spring	Bighorn Dolomite, Gallatin Limestone, Gros Ventre Fm, and Flathead Sandstone
	STAR VIEW ESTATES	5600893-101	P56978W	168	Well	Salt Lake Fm
	TARGHEE NF TRAIL CREEK CAMPGRD	5680116-101		0	Well	
	TETON GABLES	5601152-101	P10299	0	Well	
	TETON SHADOWS HOME OWNERS ASSN	5600724-101	P76779W	31	Well	terrace
	TETON VALLEY RANCH CAMP	5600524-101	P15156W	196	Well	Alluvium
	TETON VALLEY RANCH CAMP	5600524-102	P15158P	60	Well	Alluvium
	TETON VILLAGE KOA	5600520-101	P15658W	62	Well	
	TETON VILLAGE WTR & SWR DIST.	5600218-102	P100143W	170	Well	Alluvium/ Colluvium
	TETON VILLAGE WTR & SWR DIST.	5600218-101	P100142W	164	Well	Alluvium/ Colluvium
	THAYNE, TOWN OF	5600159-101		0	Spring	Salt Lake Fm
	THAYNE, TOWN OF	5600159-102	P130958W	272	Well	Salt Lake Fm
	VIRGINIAN LODGE	5600684-101	P1566W	150	Well	
	VISTA GRANDE	5600683-101	P42529W	70	Well	
	WY TRANS DEPT STAR VALLEY RA	5600952-102	P115323W	50	Well	Terrace
	WY TRANS DEPT STAR VALLEY RA	5600952-101	P51918W	325	Well	Salt Lake Fm
	YELLOWSTONE NP LEWIS LAKE CG	5680081-101		139	Well	Rhyolite flows, tuff, and intrusive igneous rock

8.6.3.8 Industrial use

Table 8-6 lists seven SEO permits for industrial (IND) use; only one industrial use permit is listed for Idaho in the Snake/Salt River Basin. Primary industrial uses in the Snake/Salt River Basin have included construction companies and aggregate and gravel mining. The SEO database does not identify specific industrial uses; individual permit summaries must be reviewed for that information. **Figure 8-5** shows the distribution of likely drilled industrial use permits in the entire Snake/Salt River Basin issued before and after January 2003.

8.6.3.8.1 Oil and gas production, injection wells and WYPDES outfalls

Groundwater associated with oil and gas production includes "produced water" withdrawn as a byproduct of oil and gas extraction from hydrocarbon reservoirs, and water utilized in the production and refining of petroleum resources. In some cases, produced water is used in production and refining operations; in others, water for operations is obtained from surface or underground sources. Some water plans (e.g., the 2012 Wind/Bighorn River Basin Water Plan) have treated produced water withdrawals as industrial groundwater use, while others (e.g., the 2006 Platte River Basin Water Plan) have included only water used for production and refining operations in estimates of industrial use. Information on currently produced water associated with conventional oil and gas operations was obtained from the WOGCC website: http://wogcc.state.wy.us/.

Figure 5-4 shows the locations of conventional oil and gas infrastructure in the Snake/Salt River. WOGCC records show that all oil and gas wells in the Snake/Salt River Basin are plugged and abandoned and that no production has occurred during the last three decades (**table 8-1b**; WOGCC, 2013). There is, however, a gas pipeline that runs from the northern Green River Basin to Jackson. **Figure 5-5** shows the locations of Class V and other injection wells, in the Snake/Salt River Basin. The WDEQ permits Class V wells for disposal of non-hazardous wastewaters from a variety of sources. Most injection permits in the basin are for Class V facilities used for heat pump return flows and the disposal of septic and storm water effluents.

Figure 5-6 shows the location of WYPDES outfalls and WDEQ groundwater pollution control facilities.

Effluent waters from various facilities of suitable quality can be put to beneficial use (e.g., stock watering, agriculture, drilling, and industrial dust suppression). Otherwise, effluent water is primarily discharged to the surface under the regulation of WDEQ NPDES/WYPDES permits. WDEQ data indicates that most WYPDES permits in the Snake/Salt River Basin are issued for municipal wastewater lagoons for the towns of Jackson and Thayne. Estimates of the volume of produced water discharged in the Snake/Salt River Basin under the WYPDES program are not readily available.

Water volumes that are discharged to the surface or put to other uses are generally considered to be partially-consumptive and, in a few cases, wholly consumptive. Almost every effluent water management strategy involves some consumptive losses to evapotranspiration. On the other hand, injecting effluent water into hydrogeologic units at depths where there is minimal chance of future withdrawal effectively removes it from the water budget of the basin and is wholly consumptive. Effluent waters discharged to the surface under a WYPDES permit generally add to streamflows and increase the growth of vegetation. The water balance developed within this study did not consider effluent water on either side of the equation.

8.6.3.8.2 Groundwater use for non-energy minerals development

Groundwater withdrawals for non-energy minerals development in the Snake/Salt River Basin are primarily associated with sand, gravel, and limestone production. **Figure 5-8** shows the locations of groundwater permits for these uses in the Snake/Salt River Basin. Mining permits can be viewed on WDEQ Land Quality Division website: http://deq.state.wy.us/lqd_permit_public/.

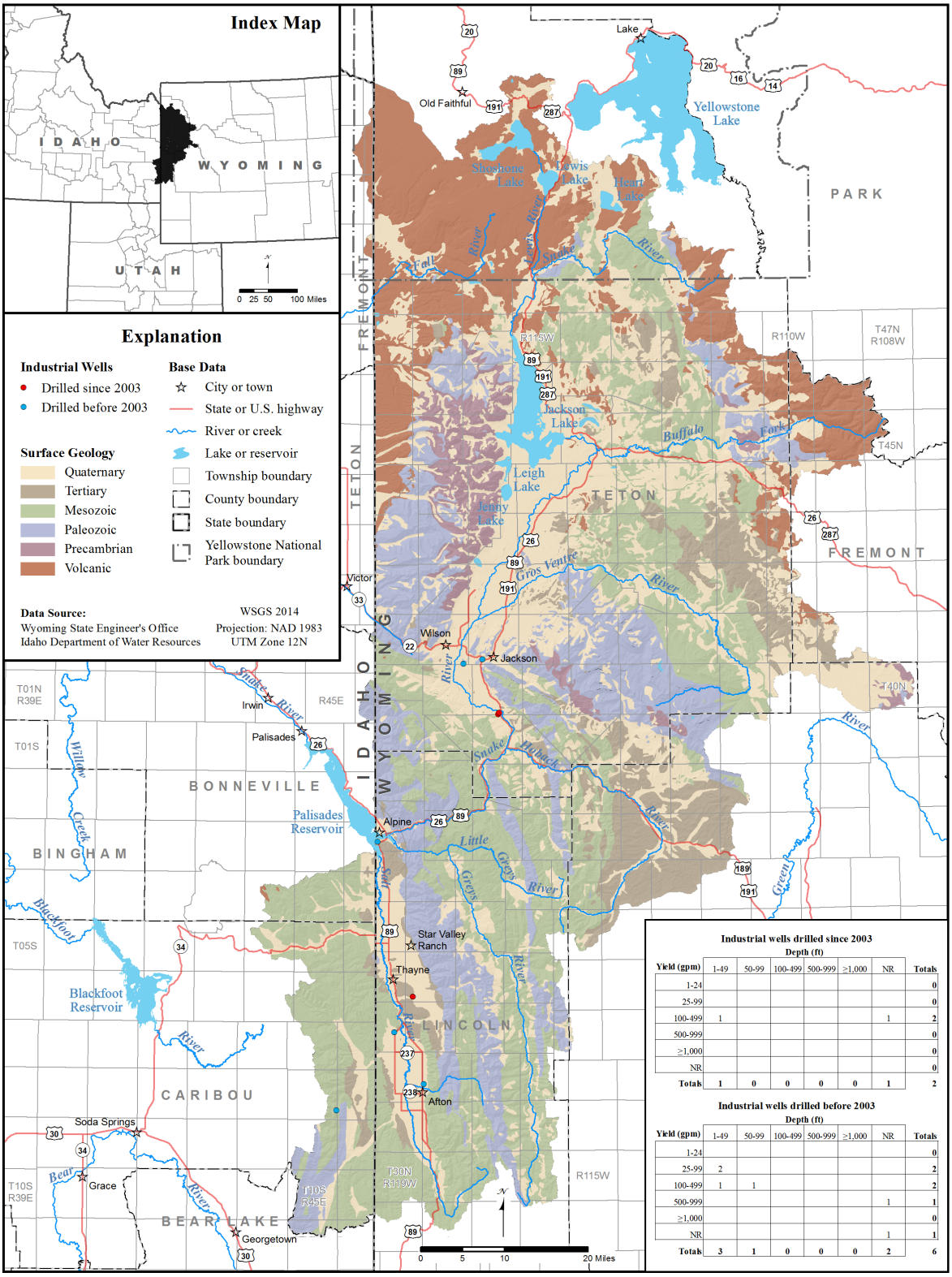

Figure 8-5. Wyoming SEO and Idaho DWR permitted and drilled industrial wells, Snake/Salt River Basin.

8.6.3.9 Monitoring wells

Table 8-6 lists 677 SEO groundwater permits for monitoring wells in the Wyoming part of the Snake/Salt River Basin; **table 8-7** shows thirty monitoring wells in Idaho. Monitoring wells are typically used to monitor the levels and the quality of groundwater associated with a contaminated site or a potentially contaminated site (e.g., an underground fuel storage tank) or to monitor for groundwater impacts from various activities (e.g., mining or waste management). When used for monitoring alone, these wells have no permitted yield; however, there may be a permitted yield for other, secondary uses. The SEO required permits for monitoring wells of four inches or less in diameter only through 2004; therefore, the data for these permits are incomplete.

Figure 8-6 shows the distribution of likely drilled SEO monitoring well permits in the Snake/Salt River Basin and permits issued before and after January 2003. Most monitoring wells are located in alluvial units near Jackson or in the Salt River Valley. The depth vs. yield tables on **figure 8-6** show that while permits have been issued for all depth categories, by far the largest number were issued for depths up to 50 feet reflecting monitoring of the shallow water table aquifers that are most susceptible to contamination. Although, recorded depths are available for most monitoring wells in the database, only nine well permits include recorded yield data. Only 35 monitoring wells were permitted after 2003; however, as discussed above, this number is probably understated, per the 2004 SEO policy change.

8.6.3.10 Permits for other and miscellaneous uses

Table 8-6 indicates that 905 permits have been issued for "other" uses and 532 permits for "multi-use" wells have been granted by the SEO (**table 8-6**). Multi-use permits list more than one use; for example a permit that shows both "domestic and "stock" use is a multi-use permit. **Table 8-7** lists six IDWR permits for "other" wells and one "multi-use" permit issued by the IDWR. Some of the "multi-use" permits issued are for test wells generally employed for aquifer testing to determine aquifer characteristics. Information on specific miscellaneous use and test wells may be found in some permit applications available online. However, developing detailed information for specific miscellaneous use and test wells was beyond the scope of this study.

Figure 8-7 shows the distribution of likely drilled wells permitted for "miscellaneous use" and "other" wells in the Snake/Salt River Basin, and permits issued before and after January 2003. "Miscellaneous use" and "other" wells are located throughout the Snake/Salt River Basin and are generally concentrated along rivers and their larger tributaries. The depth vs. yield tables on **figure 8-7** show that most groundwater permits have been issued for depths up to 500 feet and for yields of one to 99 gpm for both total permits and permits issued since 2003. A fraction of these permits have no recorded depth.

8.6.3.11 Hydrothermal use

The geothermal resources of the Snake/Salt River Basin are of the high-low-temperature hydrothermal type, occurring where groundwater exists at anomalously elevated temperatures (relative to the average geothermal gradient). Although, the Yellowstone Plateau is characterized by major high- and low-temperature geothermal features. These occurrences are not typically found at a depth where they can be put to beneficial use. Hydrothermal resources of the Snake/Salt River Basin are primarily suited to local, small-scale projects that utilize low-temperature waters for space-heating, de-icing, and recreational/therapeutic applications (e.g., Granite Hot Springs).

8.7 Groundwater interference/ interconnection with surface water

The potential for interference between wells and well fields located within areas of interconnected surface and groundwater that exhibit historically high levels of drawdown must be considered when assessing the historic, current, and future use of groundwater in the Snake/Salt River Basin. These issues, however, are not as significant in Snake/

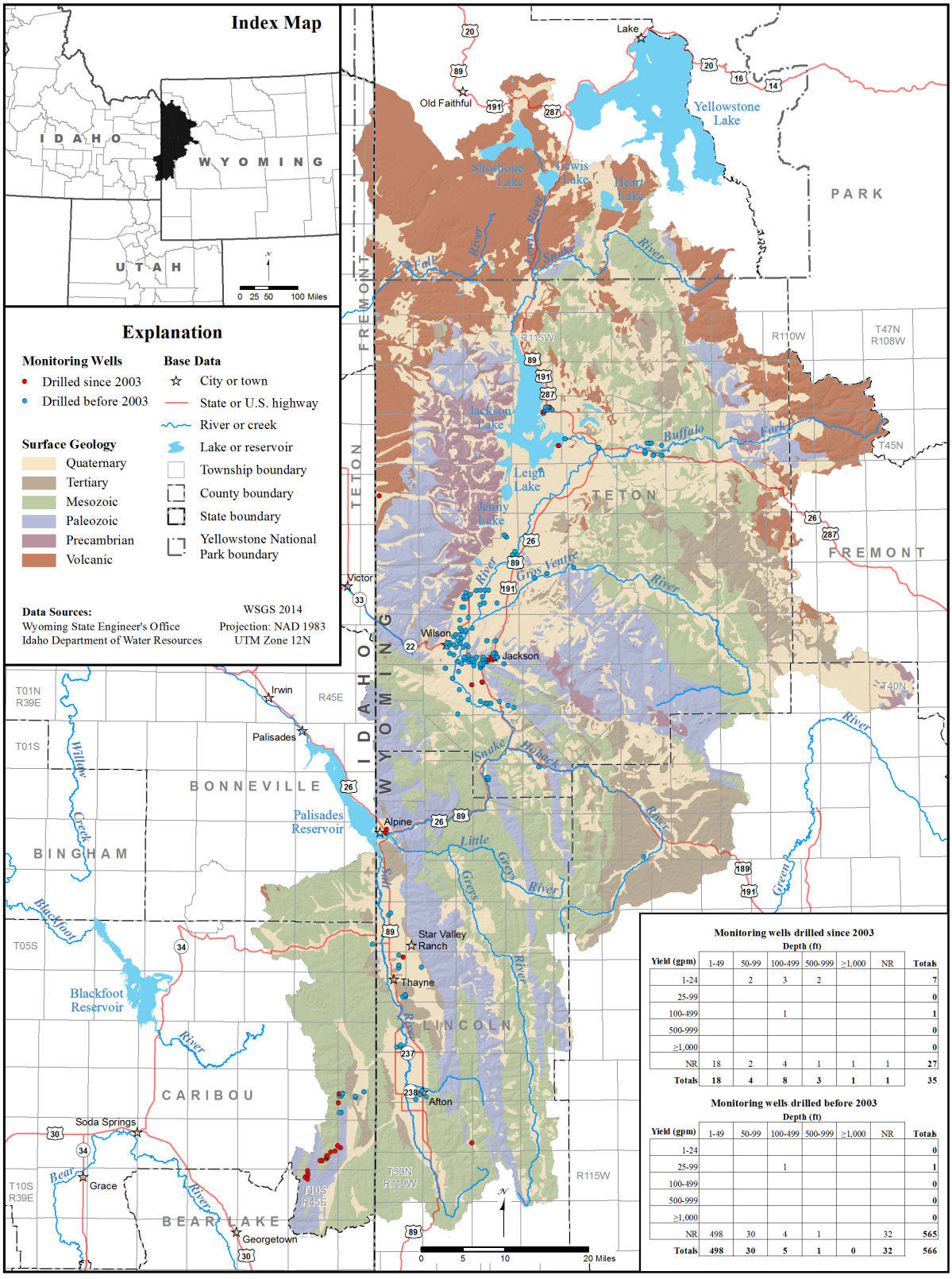

Figure 8-6. Wyoming SEO and Idaho DWR permitted and drilled monitoring wells, Snake/Salt River Basin.

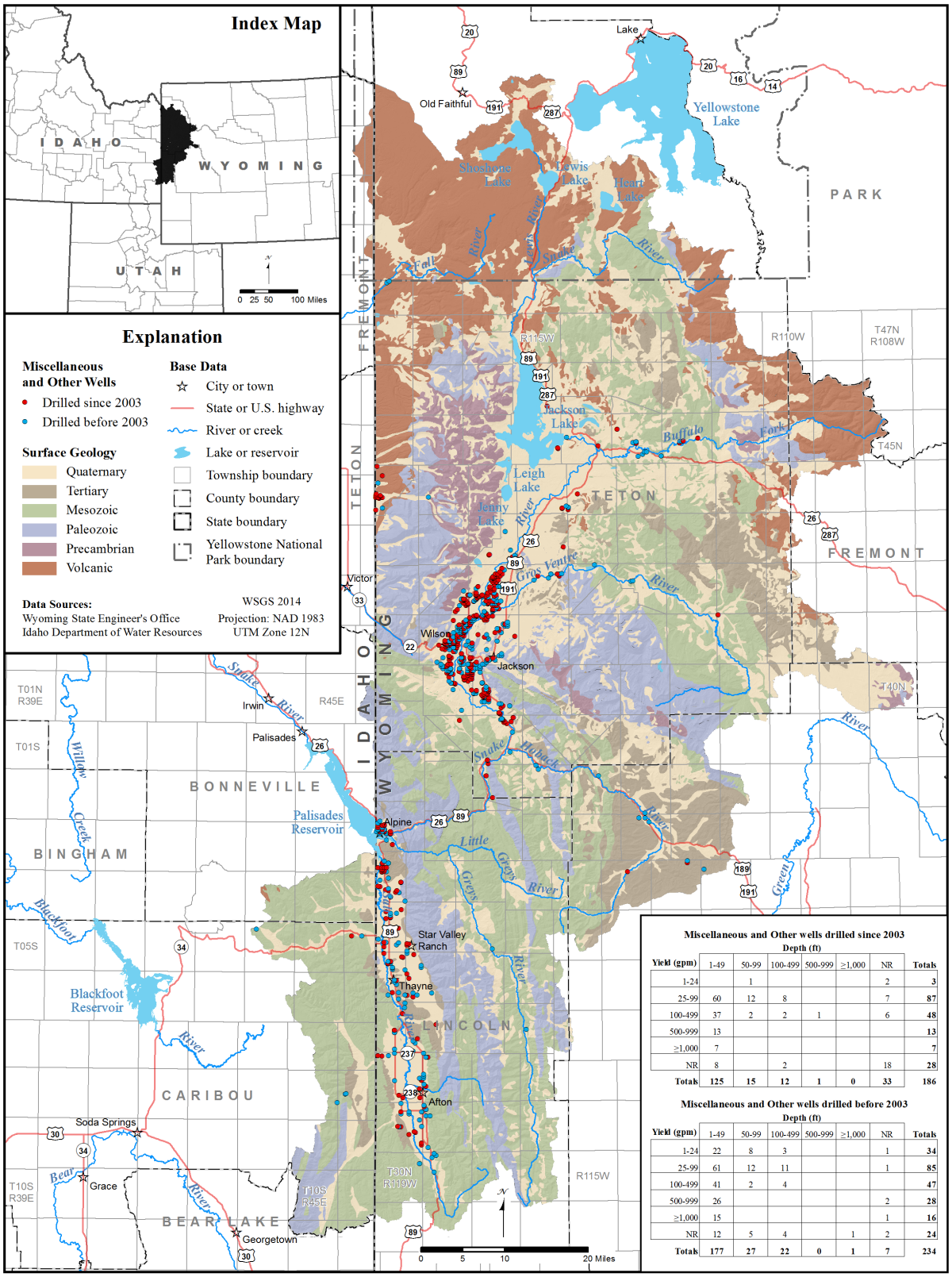

Figure 8-7. Wyoming SEO and Idaho DWR permitted and drilled miscellaneous and other wells, Snake/Salt River Basin.

Salt River Basin compared to Wyoming's more arid river basins. The use of groundwater resources is not addressed in the Snake River Compact of 1949 (**appendix D**).

8.7.1 Interference between wells

As a well withdraws water from an unconfined aquifer, it depresses the groundwater level around the well casing in a generally radial configuration, called a "cone of depression". In areas where several actively pumping wells are sited in close proximity to each other, their respective cones of depression may overlap and "well interference" may result. If well interference becomes excessive, aquifer water levels may drop below the depth of some wells causing conflicts between users. In Wyoming, the SEO may address cases of excessive well interference by recommending the formation of a groundwater control area wherein groundwater uses are actively managed by a groundwater control area advisory board. According to Wyoming State Statute WSS 41-3-912, a "control area" can be designated by the Board of Control on the recommendation of the State Engineer for any of the following reasons:

- The use of underground water is approaching a use equal to the current recharge rate.
- Groundwater levels are declining or have declined extensively.
- Conflicts between users are occurring or are foreseeable.
- The waste of water is occurring or may occur; and
- Other conditions exist or may arise that require regulation for the protection of the public interest.

Currently, there are no control areas designated in the Snake/Salt River Basin. Additional information about groundwater control areas can be found online at: https://sites.google.com/a/wyo.gov/seo/ground-water/groundwater-control-areas-advisory-boards.

8.7.2 Interconnection between groundwater and surface water

Surface flows are subject to strict water rights, and conflicts occur where groundwater extraction affects surface flow. Although the Wyoming Constitution establishes that all surface water and groundwater within Wyoming's borders is owned by the state, the right to put surface water and groundwater to beneficial use is permitted as water rights by the Wyoming SEO and adjudicated by the Wyoming Board of Control. Surface water resources are subject to interstate agreements that limit how much streamflow can be depleted before leaving the state. Furthermore, conflicts among users within the state or across state lines can occur where groundwater extraction may affect surface flows. Although interconnection between groundwater and surface water is not currently a significant water rights issue in the Snake/Salt River Basin, it could become a point of contention in the future as the basin's population grows.

To avert present and future conflicts over the allocation and use of water flows within the Snake/Salt River Basin, the states of Idaho and Wyoming agreed to the Snake River Compact in 1949. The compact controls surface flows in the Snake and Salt Rivers and tributary streams. The Interstate Streams Division of the SEO summarizes the provisions of the compact as follows:

> "The Compact recognizes, without restrictions, all existing rights in Wyoming as of the date of the Compact. It permits Wyoming unlimited use for domestic and stock uses provided that stock water reservoirs shall not exceed twenty ac-ft in capacity. It permits Wyoming to divert (or store) for new developments, either for supplemental or original supply, four percent of the Wyoming-Idaho state line flow of the Snake River.
>
> Use of the water is limited to diversions within the Snake River drainage basin unless both states agree otherwise.

> The Compact gives preference to domestic, stock and irrigation uses of the water over storage for the generation of power."

Appendix D (SEO, 2006) contains a copy of the Snake River Compact of 1949. The Interstate Streams Division of the SEO administers the provisions of the compact that fall under the authority of the state of Wyoming. Further information is available online at: https://sites.google.com/a/wyo.gov/seo/interstate-streams/know-your-basin/snake-river-basin.